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EFFICIENCY OF THE TRANSFORMER SYSTEM.

OUR readers will recollect some of the utterances which were made respecting the above while raged last year the battle of the accumulator and transformer systems in the theatre of the Institute of Civil Engineers. In the paper of Mr. Swinburne, read at the British Association meeting, and published in our last issue, this question is again reopened, and there is little doubt that during the coming winter we shall hear it discussed pretty freely.

In the paper referred to it is maintained that a return to the open magnetic circuit transformer would be, in many instances, beneficial—a somewhat revolutionary idea which demands much careful study and investigation before acceptance; but that transformers have been generally designed without regard to the varying conditions of working we are fully aware, and the sooner the practice is discontinued, and apparatus designed with strict regard to economy under the actual conditions of working, the sooner will the debit account to the transformer station be diminished.

Unfortunately we have but few figures on which to estimate the efficiency of a transformer system, and our computation necessarily lacks the precision which would be given by figures obtained from the working of an actual station. The efficiency of the transformer itself has been estimated at various amounts. "I think there is a general idea," said Prof. Forbes, in his recent paper, "that any of the converters now on the market in England will give an efficiency for the average number of lamps in use of about 90 to 95 per cent. I should be much surprised if there were more than two types in use in this country which have an efficiency for the average number of lamps of over 70 per cent." A number of very careful efficiency tests was made on a transformer by Prof. Ayrton some time ago, the method of measuring the power wasted being by calorimeter, which, so far as we know, is liable to the fewest objections. The results obtained by the Professor were, for the full output of the transformer, 1,500 watts, 96 per cent; for two-thirds load, 94 per cent.; half load, 90 per cent., and one-third load, 85 per cent. At quarter load the efficiency was about 80 per cent. Now here is a transformer in which the variation is from 80 per cent. at quarter, to 96 per cent. at full load. It may be regarded as fairly typical of the closed magnetic circuit class of apparatus. The tests were made with great care, and the figures are certainly the most reliable we have. But evidently the efficiency here talked of is not what we have to deal with when considering the efficiency of the transformer system as a whole, and it is not what Prof. Forbes had in his mind when he spoke of 70 per cent. Here there is taken simply the ratio of the rates of receiving and expending work, and though for a transformer with a uniform load this represents quite accurately the ratio of work received to work expended over a given period, it is evident that when the load is constantly varying these figures of percentage afford little information regarding the actual commercial efficiency of the apparatus. It is useless to say that the efficiency of a transformer is 90 per cent. at half load if its secondary circuit is closed with this load for only four hours per diem, no notice being taken of the energy wasted in reversing the magnetism of its core for the other 20 hours. Such statements are only misleading, and it is doubtless with a view to clear away some of the mental fog respecting the real efficiency of transformers that Mr. Swinburne writes his paper. The energy expended in the primary during the whole of the 24 hours must be debited to the transformer, while on the credit side we have the energy appearing in the secondary during the hours of lighting. The ratio of the latter to the former is the true commercial efficiency of the apparatus, and it is upon this ratio that the efficiency of the transformer system, as a whole, mainly depends.

Let us look at this matter a little closer. We turn to the figures in the *Journal* of the Institution of Electrical Engineers, and find that the particular transformer to which we have referred required an expenditure of

53·18 watts when the secondary circuit was open. We will imagine that the transformer is loaded for six hours out of the twenty-four, the secondary circuit being open for the remaining 18. This puts 53·18 × 18 = 957·24 watt-hours on the debit side of the account. If the load is maintained at the maximum for two hours, at two-thirds for two hours, and at one-third for two hours, the efficiencies are 96, 94, and 85 per cent. respectively. We take this as a fair estimation of the loading, and we get the following: Expended during two hours at full load, 3,125 watt-hours; during two hours at two-thirds load, 2,126 watt-hours; during two hours at one-third load, 1,176 watt-hours, which, with the 957 watt-hours for the 18 hours, make a total of 7,384. This is in round figures, and giving the account the benefit of the fractions. Now, for the receipts we have at full load 3,000 watt-hours; at two-thirds, 2,000 watt-hours; and at one-third, 1,000 watt-hours; total, 6,000 watt-hours; Efficiency, 81 per cent.

These figures may be objected to on the grounds that we have assumed full load for too great a proportion of the total time of lighting, and that there may be a period during which the load falls considerably below one-third of the maximum. The criticism is probably a just one, but in giving these figures we wish to place the transformer at the greatest advantage. In practice we do not get the time divided into two-hour periods as here assumed, and for the actual variation under different loads a calculation to suit the actual conditions must be made.

Our object in bringing these figures to the notice of our readers, has been to show that the usual way of estimating the efficiency of a transformer is wrong, that the ratio of the work being received to the work being expended at any instant is not the commercial efficiency, and that the correct method of obtaining this is by taking the ratio of the work received from and given to the transformer throughout the whole period of its connection to the primary circuit. As an example, we have taken a period of 24 hours, for six of which the transformer is loaded, but it will be obvious that for the summer time this number of lighting hours is too great. It might fairly represent the amount of light required in the winter, but in the summer the hours would be less, and the efficiency therefore lower. It is evident, then, that the efficiency should be estimated on the basis of 12 months continuous working. Taken on this basis, and allowing for the fact that large transformers are more efficient than small ones, we imagine that an estimate of from 70 to 75 per cent. efficiency will be found very near the truth.

So much for the transformer losses, but the waste in other parts of the system must be found before we ascertain the efficiency of the whole. From the most reliable tests made it seems that there can be obtained on the crank shaft of a first-class compound engine from 90 per cent. of the indicated horse-power at full load to about 80 per cent. at half load. The percentage necessarily alters with every varying condition of working, but roughly 85 per cent. may be assumed as the average return. The dynamos we may take as having a commercial efficiency of 90 per cent., and this makes the electrical output at their terminals average 76·5 per cent. of the I.H.P., assuming that the engines are directly coupled, or allowing for the loss in belting direct we may put it down at 72 per cent. For the ratio of the E.H.P. to I.H.P. a value very close to this has been determined by several experimenters, so there is little doubt about its approximate accuracy. The loss in the mains may be merely fractional, so we will not now take it into account. Taking the average efficiency of the transformers at 75 per cent. then, we get 54 per cent. as the efficiency of the whole system; that is to say, the watt-hours received in the secondaries of the transformers are rather over half the number of watt-hours expended in the engine cylinders.

As we said at the beginning, we have before us no records of actual working, and the figures given are more or less hypothetical. But estimates must be based on some figures before the central station is an accomplished fact, and it seems to us that engineers in computing the useful return should not reckon on a higher efficiency under actual working than 50 per cent. We doubt whether even this is attained as a general rule. The 18·6 lbs. of coal used at Brighton per electrical horse-power hour seem a very bad case, and we trust though these are figures from actual work that they are figures capable of vast improvement. With more care taken to design transformers in accordance with the hours of lighting farther improvement may be effected, but for obvious reasons progress in this direction is limited. We require the light for much longer periods in winter than in summer, and it is our misfortune that we cannot have a summer and winter set of transformers, the latter of which might be thrown out during the spring cleaning and reinstalled in the autumn. We must be content with transformers which for the whole twelve months give a fair average efficiency.

In conclusion, let us hope that those of our friends having actual figures in their possession will not hesitate to bring them forward. Need we say that it will give us the greatest pleasure to see discussed in these columns a subject of such growing importance?

WITH reference to the efficiency of distribution systems, we have before us a pamphlet issued by the Electrical Power Storage Company describing very fully their system of distributing electricity by the aid of storage batteries. The unfortunate Brighton figures are, of course, referred to, the company observing that the consumption of coal on their system will, under no circumstances, exceed 11·19 lbs. per E.H.P. hour supplied to the consumer. The plan of distribution consists in employing at the central station separately excited dynamos of about 500 volts placed in series, according to the requirements of the district, until the limiting difference of potentials for the charging circuit is reached. Storage or sub-stations are placed at convenient points in the district, these being all connected to the distributing mains in parallel or on the three-wire system. The cells in each station are divided into sets of 54, suitable for feeding lamps of 100 volts, and half the number of sets is charged in series, while the other half is connected in parallel to supply the lamps, only half the battery being therefore in the charging circuit at a time. When the charging of half the battery is complete the current is switched automatically on to the other half, while the sets of the charged half are placed on to the lamp circuit. In each sub-station there is placed a continuous current transformer to augment the capacity, the charging current from the dynamos feeding these during the maximum hours of lighting. The system seems to have been well thought out, and there are given comprehensive estimates of both first cost and working expenses, which we may notice on another occasion.

Modern Light and Heat, of Boston, predicts "that ere long, in view of the steady increase in the use of the electric motor, we shall see central stations equal to those at present used for lighting devoted entirely to the generation of the electric current for power purposes." Without hinting that our contemporary is over sanguine, we only wish that we could predict with truth such a state of things for this effete monarchy of ours.

IT is a pity that the three societies named below should have held their meetings so close together, as this tends to diminish somewhat the interest in such assemblies. Those persons connected with one society are generally directly or indirectly associated with the others—consequently, without a suitable interrval between the meetings, the interest of those concerned decreases, and we have as a result papers brought forward which are not up to the anticipated standard. This has been demonstrated at the Paris Electrical Congress, the British Association, and again this week at the Paris meeting of the Iron and Steel Institute, which opened on Tuesday last. The only electrical paper read before the latter was "On the Thomson Process of Electric Welding," and the members were shown the process in operation in the main aisle of the Machinery Hall at the Exhibition.

AS will be seen from an article in another part of the present issue, the Bradford Corporation have officially inaugurated the central electric light station in that town. This is the first practical step taken in this country by a Town Council and it is very probable that others will follow the example set them by Bradford. Already the municipalities of Leeds, Barnsley, Manchester, Salford, Dublin and others are considering the subject, and the work done in Bradford will doubtless have its effect.

"*C'est une ouvrage de longue haleine*," said one competitor to another, referring to the motor competition instituted by *Industries*. "Yes! it is a long job," replied the electrician addressed, "but the prize will be awarded shortly. I was round at —— the other evening when Edison's phonograph was exhibited in operation, and the instrument actually rolled out the words: 'Well, it is agreed, then, that although the designs are not up to the standard required by our conditions, that by —— is the best, and must have the prize; but we must in future have no more competitions of a similar nature. The award will therefore shortly ——.' I could hear no more, as the sounds were indistinct." Our office boy, who brought us this astounding information, says that he thinks somebody will get the prize before the end of the year. Those of our readers who are interested in the matter would do well to bear this in mind.

MR. PREECE, it appears, in his recent remarks before the British Association, did not intend to convey the notion that death could not be produced with certainty by the electric current, though there can be no question that a statement was made to this effect, and, moreover, the statement that the American law with reference to execution by electricity would have to be rescinded, seems to bear out what he was understood to say. However, we hear that what Mr. Preece meant was—that the current strength required to produce death with certainty, and without torture, was not yet determined. Possibly this may be the case, but we ourselves have no doubt that ample evidence exists to show how instantaneous death can be produced by the current.

IN the discussions which have from time to time taken place, and notably at the late meeting of the British Association, on the dangers of electric lighting, special stress has been laid upon the high voltage causing the shock, as if this were the one element of danger, though, on the other hand, it has been brought forward as an argument against the danger theory that shocks from an enormously high voltage have been taken with impunity. It seems to be forgotten that high voltage is but the element tending to cause a strong current to be set up through a high resistance, and that what causes danger is the *continuance* of a current of a certain strength for a certain time, through the human body. A low potential cannot set up a strong current because the resistance it has to encounter in the human body is great, but a high potential can set up and maintain a strong current, *but only provided this high potential lasts for a certain period*. High potential alone cannot *maintain* a strong current, thus a Leyden jar of an exceedingly small size can be charged to an enormously high potential, a 100,000 volts, or more, but the duration of the current which it will cause to flow when the jar is discharged is an infinitesimally small period, a time much too short to enable any very marked pysiological effect to be produced. The same is the case with the shock received from a Rhumkorff coil; the latter gives a spark, say, half an inch long, the potential which causes this spark must be many thousand volts, but the shock which the coil will give, even when continually applied, would not (except in special cases) cause death, simply because the high potential only sets up a current for an extremely short period. The case, however, is totally different with a high potential dynamo; here the high potential which sets up the current can, and does, maintain the latter for a considerable period, and this passing through the human body will, in most cases, produce a fatal result.

THE more one reads of the proceedings of the Paris Congress with reference to electrical standards, the more one wonders how that absurdity, the "Legal Ohm," ever came to be authorised. To substitute one incorrect value for another certainly does not improve matters, for it is known that the legal ohm is not the true ohm. As a matter of fact, the legal ohm has never, and never will, come into use, and will only continue to exist as a name.

THE ZIPERNOWSKY ELECTROSTATIC ELECTRO-MOTOR.

[BY A CORRESPONDENT.]

THE well-known phenomenon that bodies charged with identical electricity repel each other, was first used in 1780 by Franklin for the production of continuous motion. He employed a horizontal wheel constructed of horizontal strips of glass fitted at each end with copper balls. The wheel was placed upon a point between the balls of two Leyden jars with opposite charges, so that two diametrical balls of the wheel became charged similarly with those of the jars and were consequently repelled by the latter. After a revolution of 180°, each ball discharged itself on the ball of the opposite Leyden jar, receiving at the same time a part of the electricity there accumulated, and was repelled. Franklin named this apparatus an electrical kitchen jack.

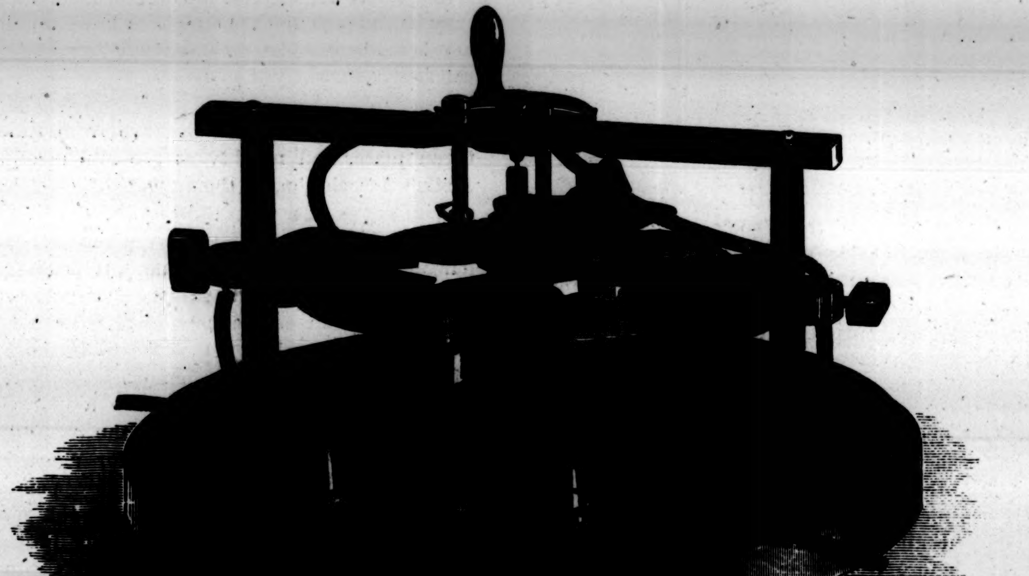

FIG. 1.

Poggendorff subsequently showed that a movable disc of glass or ebonite begins to rotate if opposite electricities are conveyed to it by means of two diametrically opposite combs, and if at the same time it receives an initial impulse in any direction.

Poggendorff also set a Holtz influence machine in rotation by charging the combs of this machine by another influence machine.

In order to study the so-called static effects of high tension alternating currents, Herr Zipernowsky, amongst others, has constructed a small rotatory apparatus which he derived from Thomson's quadrant electrometer in the idiostatic form indicated by Joubert. Zipernowsky has been able to set this apparatus in rapid motion both with a high tension alternating current and with a high tension continuous current. In the former case he introduced the apparatus between the secondary terminals of a transformer whose primary was connected to an alternating current machine of low tension. With 1,000 volts the rotation was so rapid that it could not be followed with the eye.

In the second case he took the electricity from a driving band which connects the shafting in the testing room of the electrotechnical department of Ganz & Co.'s establishment with the motor, a high speed steam engine. In this case the number of rotations was much greater than with a 2,000 volt alternating current.

Fig. 1 gives a perspective view of this small motor, and fig. 2 a diagrammatic representation, with the arrangement of connections shown in both the cases.

The movable part of the apparatus consists of two pairs of aluminium sectors, insulated from each other, which, for the sake of perspicuity, are represented in fig. 2 as the quadrants, A A′, B B′. The fixed part consists of four double (hollow) sectors of brass, which enclose the movable sectors, and which are also shown in the diagram as the quadrants, C C′, D D′. The movable part is further fitted with a commutator in four parts, by means of which the two pairs of sectors, A A′ and B B′, are charged identically with the opposite fixed pairs of sectors by means of the points, S S′. If the clamps, K K′, are connected with the terminals, S S′, of the transformer, T, which converts the low tension of the alternating current machine M, into a high tension, the apparatus begins to revolve spontaneously unless the movable sectors are placed exactly opposite to the fixed ones. The same takes place if one clamp is connected

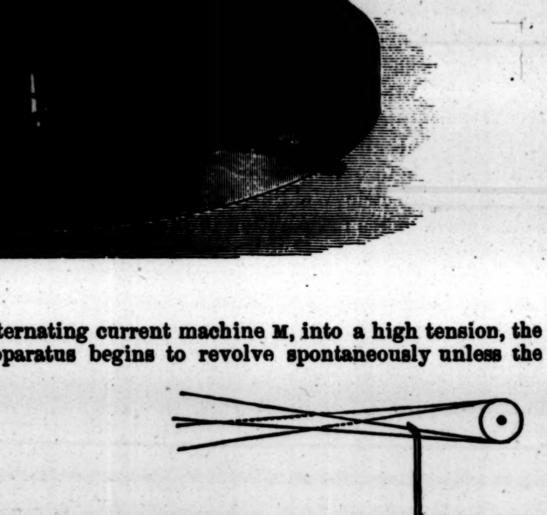

FIG. 2.

with the receiving device, V, and the other is connected with the earth. It must be remarked that in this second arrangement a momentary charge of the movable sectors would suffice, as the fixed segments do not alter the sign of their charge. In the former arrangement the charge must be continued, so that the electricities in the fixed and the movable parts may change their signs simultaneously.

It is possible that this apparatus, in some form or other, will be suitable for practical purposes, *e.g.*, as a volt-counter for arc lamps in series, as a registering apparatus for the resistance of earth connections, or for changes in the primary tension in alternating current circuits, and perhaps in the case of very high tensions as a motor.

REVIEW OF THEORIES OF ELECTRICAL ACTION.[*]

By Prof. H. S. CARHART.

THE physics section of this association congratulates itself because it deals with topics of the most lively and general interest, not only from a practical point of view, but still more from a theoretical one. Even popular interest in electricity is now well nigh universal. Its applications increase with such prodigious rapidity, that only experts can keep pace with them. At the same time, the developments in pure electrical theory are such as to astound the intelligent layman, and to inflame the imagination of the most profound philosopher.

Of the practical applications of electricity it is not necessary to speak. They bear witness of themselves. A million electric lamps nightly make more splendid the lustrous name of Faraday; a million messages daily over land and under sea serve to emphasise the value of Joseph Henry's contribution to modern civilisation. Blot out these two names alone from the galaxy of stars that shine in the physical firmament, take from the world the benefits of their investigations, and the civilisation of the present would become impossible. The value of the purely scientific work of such men is attested by the resulting well-being, comfort, and happiness of mankind.

But the mind can never rest satisfied with the facts and applications of a science, however interesting and useful they may be. It feels an inward impulse to link the facts into a related whole, to enquire into their causes, to frame a satisfactory theory of their correlation, and so to build on them a true science. It is, indeed, interesting to study the history of any scientific doctrine, and to trace its development from the crude notions of its earliest stages to the more refined conceptions of later periods, comporting indefinitely better with the marvellous processes of nature. Such a history we have in the views which have been held regarding the nature and action of electricity. The transition from the glutinous effluvium of the sagacious Robert Boyle to the magnetic and electric waves of the present, traversing the omnipresent ether with the velocity of light, is not an easy one to make, even in a period of 200 years. For more than 20 centuries natural philosophers had nothing better than the emission theory to account for the attraction exhibited by rubbed amber and other similar substances. Their notion was that the rubbing of the amber caused it to emit an effluvium which returned again to its source, and carried light bodies back with it.

In one respect this fanciful attempt to explain electrical attraction deserves commendation, for it evinces a mental inaptitude to account for physical actions "at a distance," or without some intermediate agency. Later philosophers, satisfied perhaps too easily with mathematical explanations founded on the observed laws of attraction and repulsion, and not demanding a medium, did not feel the same intellectual necessity of filling the space between bodies acting on one another, either with emanations from those bodies or with an invisible, imponderable medium, suspected by no sense of man, but required only to meet a demand of his highest intelligence. For when the Newtonian philosophy had made some progress, the doctrine of unctuous effluvia was given up, and physicists acquiesced in the unexplained principle of attraction and repulsion as properties of certain bodies communicated to them by the Divine Being, the mechanism of which they scarcely attempted to explain. "Many superficial philosophers thought they had given a very good account of electricity, cohesion and magnetism, by calling them particular species of attraction peculiar to certain bodies."[*]

The discovery by Stephen Grey that "the electric virtue" could be conveyed along a wire for several hundred feet without sensible diminution, and the invention of the Leyden jar by Kleist, or Cuneus, had the effect of annihilating many mushroom theories constructed on the slimmest basis of facts. The latter discovery disclosed a power in electricity not previously suspected, and excited the greatest interest in both Europe and America. At this period Franklin turned his attention to the subject, and "spent more time in diversifying facts and less in refining upon theory" than some of his European contemporaries. In fact, he tells us that he was never before engaged in any study that so totally engrossed his attention and his time. His discovery that the two electricities are always excited in equal quantities, that the charge resides on the glass and not on the coatings of the Leyden jar, and his experimental identification of lightning with frictional electricity excited the liveliest interest abroad, and secured for him the Copley medal of the Royal Society; while his theory of positive and negative electricity made a permanent addition to the nomenclature of the science. His conceit that a turkey, killed with the discharge of a battery of jars, was uncommonly tender eating—a discovery gravely communicated to the Royal Society by William Watson—is not so well known, and does not appear up to the present to have been verified.

We cannot agree with him, I am sure, when he says: "Nor is it of much importance for us to know the manner in which Nature executes her laws; it is enough if we know the laws themselves." For the pursuit of the manner in which Nature executes her laws is the distinguishing characteristic of the science of the present day. It has led to most brilliant discoveries, and bids fair to do more than all other agencies combined to show the intimate and necessary relations existing between the different branches of physics. We need to be reminded often that accumulated facts do not constitute a science; and that utility is not the highest reward of scientific pursuits. A bit of polished marble plucked from the ruins of the Roman Palatine Hill is an interesting relic; but how much more interesting to reconstruct the palace of Nero and to see this fluted marble in its proper and designed relation to the whole, of which it was once a necessary part! Science is constructive. Laws are derived from an attentive consideration of facts; generalisations group laws under broader relationships; and great principles unite all together into one related, impressive whole.

From the time when the famous Boyle caught sight of a faint glimmer of electric light to the present physicists have been in pursuit of the connection between light and electricity. As early as Newton's time the ether was conceived by some to be a subtle medium confined to very small distances from the surfaces of bodies, and to be the chief agent in all electrical phenomena. "But," says Priestley,[†] "the far greater number of philosophers suppose, and with the greatest probability, that there is a fluid, *sui generis*, principally concerned in the business of electricity. They seem, however, though perhaps without reason, entirely to overlook Sir Isaac Newton's ether; or, if they do not suppose it to be wholly unconcerned, they allow it only a secondary and subordinate part to act in this drama." Among the branches of knowledge that this writer recommends as likely to be of especial service in the study of electricity is the doctrine of light and colours. The invention of the voltaic battery and Sir Humphrey Davy's celebrated experiment in producing the electric arc stimulated enquiry in this same direction. Mrs. Somerville, Morrichini, and others sought to produce magnetism by means of sunlight, but ultimately, as is now known, without success. Notwithstanding these negative results, Faraday had such a "strong persuasion derived from philosophical considerations" of a direct relation between light and electricity that he resumed the inquiry in a most searching manner, with the happy result of discovering the rotation of the plane of polarisation of light by means of magnetism. "Thus is established," he says,* "a true, direct relation and dependence between light and the magnetic and electric forces; and thus a great addition [is] made to the facts and considerations which tend to prove that all natural forces are tied together, and have one common origin."

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[*] Address by Prof. Carhart, Vice-President Sec. B, American Association for the Advancement of Science, delivered at the annual meeting, Toronto, August 28th, 1889.

[*] *Priestley's Hist. of Elec.*, Vol. II., p. 18.

[†] *Hist. of Elec.*, Vol. II., p. 22.

It was thus reserved for Faraday to make those discoveries and to obtain that insight into electric and magnetic action which were needed by his great disciple and interpreter, Maxwell, to construct a most marvellous theory of the connection between these two departments of physical science.

Respecting the failures to obtain magnetism from the direct action of sunlight, to which allusion has been made, Maxwell says that we should not expect a different result because the distinction between magnetic north and south is one of direction merely; that there is nothing in magnetism indicating such opposition of properties as is seen at the positive and negative poles of a battery in electrolysis; that even right and left-handed circularly polarised light cannot be considered the analogue of the two poles of a magnet, for the two polarised rays when combined do not neutralise each other, but produce plane polarised light.

It may be said, however, that if a right-handed circularly polarised ray produces magnetism in one direction, and a left-handed ray in the opposite, then the combination of the two rays may neutralise their magnetic effect inasmuch as plane polarised light may have no magnetic influence. Prof. J. J. Thomson has lately shown mathematically that a circularly polarised ray does have a magnetic effect, but that it is so small, even with strong sunlight, as to be much beyond the limits of experiment; and Mr. Shelford Bidwell has produced a bar of iron in such an exquisitely sensitive magnetic state that magnetic changes are certainly produced in it by the direct action of light. This he has secured by rendering the bar more susceptible to magnetic influences in one direction than the other. We may not, I venture to affirm, be without hope that magnetism and electric currents may yet be evoked by the direct agency of sunlight.

Faraday was deeply convinced that space had magnetic properties, and that the space or medium around a magnet is as essential as the magnet itself, being a part of the complete magnetic system. To him all magnetic and electric action took place by contiguous particles along lines of force. "What that magnetic medium, deprived of all material substance, may be, I cannot tell," he says,† "perhaps the ether." No doubt existed in Faraday's mind that these lines represent a state of tension; but whether that tension is a *static* state in the ether, or whether it is *dynamic*, resembling the lines of flow of a current between the poles of a battery immersed in a conducting fluid, was uncertain. He inclined, however, to the latter view. He was thus led to advocate, though not without hesitation, the physical nature of lines of force.

Faraday's discoveries and his method of regarding all magnetic and electric actions as propagated through a medium by means of contiguous parts have been of the utmost productiveness. They have revolutionised the science of electricity, and have been the most potent factors in the genesis of a theory, including all radiant energy, which has recently received such remarkable and conclusive confirmation. His name has become almost a household word. His earnest, unselfish life has added unnumbered millions to the world's wealth. His ideas and words, which have been instruments in the hands of philosophers, have become the current coin of the commercial tyro, who talks as glibly about lines of force and the magnetic circuit as if he really knew something about them.

Fruitful as Faraday's ideas were they yet awaited a mathematical interpreter for their highest development. A good Providence sent James Clerk Maxwell, whose brilliant mathematical ability was equalled by his philosophic insight, his poetic feeling and imagination, his profound sincerity and his great sympathy with Nature. Hear him sing at Aberdeen:—

Alone on a hillside of heather,
  I lay with dark thoughts in my mind,
In the midst of the beautiful weather,
  I was deaf, I was dumb, I was blind,
I knew not the glories around me,
  I counted the world as it seems,
Till a spirit of melody found me,
  And taught me in visions and dreams.

For the sound of a chorus of voices
  Came gathering up from below,
And I heard how all Nature rejoices,
  And moves with a musical flow,
O strange! we are lost in delusion,
  Our ways and our doings are wrong,
We are drowning in wilful confusion,
  The notes of that wonderful song.

To appreciate Maxwell's relation to theories of electrical action, it is desirable to take a retrospect of the views that have been held regarding its nature. Three periods in the history of these views may readily be distinguished. The first was introduced by Dr. Gilbert in 1600, and it lasted for about 225 years. The little that was known previous to Gilbert constitutes only the preface or introduction to the history proper. Nearly three-fourths of this period was utterly barren and unfruitful. It knew nothing better than unctuous effluvia and electric atmospheres. In the latter half of the period the Newtonian philosophy had become the orthodox doctrine. The great success attending the mathematical investigations, founded upon the law of inverse squares, naturally carried with it the acceptance of the underlying hypothesis of "action at a distance." There were not lacking, indeed, men of deeper philosophic insight who denied this doctrine, which they looked upon as entirely unphilosophical and which must utterly bar the way to any inquiry into the process by which the law is executed. Action at a distance by attraction or repulsion, varying inversely as the square of that distance, means an ultimate fact not admitting of further analysis.

The second period was one of contention. It began not with the important discovery of current electricity, nor of the electro-magnet, but with the philosophical methods and concepts of Faraday. The physical postulates of the mathematical school were entirely alien to the views which he adopted. "Faraday, in his mind's eye, saw lines of force traversing all space where the mathematicians saw centres of force attracting at a distance; Faraday saw a medium where they saw nothing but distance; Faraday sought the seat of the phenomena in real actions going on in the medium, they were satisfied that they had found it in a power of action at a distance impressed on the electric fluids."* Prior to Faraday the supporters of a medium to explain electric and magnetic action were always thrown out of court for lack of evidence; Faraday gave them a legal standing by furnishing the facts and evidence on which they could well afford to base their case.

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* Exp. Researches, 2,221.

† Exp. Researches, 3,277.

* Maxwell's Elec. and Mag., p. 10.

The corpuscular theory of light, which had shown such remarkable vitality, was now in the last stages of a fatal disease, due to indigestion and lack of assimilation. Foucault finished it off in 1865 with his crucial experiment to decide upon the relative velocity of light in air and water. The undulatory theory was thus fully established, and the doctrine of radiant energy in general began to be clearly apprehended. The grand generalisation of the conservation of energy was looming up all along the horizon of science, as the towers and spires of a great city appear to rise out of the sea to a traveller approaching the land. Victory was ready to perch on the banners of an army contending for the ether doctrine—not a decimated army, but one constantly augmenting in numbers by deserters from the enemy. At this period, sixteen years ago, appeared the epoch-making book of Maxwell on Electricity and Magnetism. Its author professes only to translate Faraday's ideas into mathematical language; but he did vastly more than this. He demonstrated mathematically that the properties of the medium required to transmit electro-magnetic action are identical with those of the luminiferous ether. It would be unphilosophical, he remarks, to fill all space with a new medium whenever any new phenomenon is to be explained; and since two branches of science had independently suggested a medium requiring the same properties to account for the same phenomena in each, the evidence for the existence of a single medium for both kinds of physical phenomena was thereby greatly strengthened. The step from identity of the medium to identity of phenomena, that is, that light itself is an electro-magnetic phenomenon, though it may now seem to be a short one, must nevertheless, upon careful consideration, always be accepted as evidence of the greatest genius. To walk in Maxwell's footsteps now and take the very steps he took is one thing, and a comparatively easy one; but to make original explorations into unknown regions of nature, and to tread where no human being has ever before set foot is quite another thing. The electro-magnetic theory of light must be regarded as a great generalisation, inferior only to that greatest one of all time—the conservation of energy.

The principal criteria upon which Maxwell relied for the confirmation of his theory may be briefly enumerated:—

1. An electro-magnetic wave or undulation is propagated through the ether with a velocity equal to the ratio of the electro-magnetic to the electrostatic unit of quantity. If light is an electro-magnetic phenomenon its velocity must also be equal to this same ratio. The very close approximation of the one to the other, as determined by a variety of methods, has been known for some time.

2. The specific inductive capacity, K, of any transparent dielectric should equal the square of its index of refraction. The discrepancies at this point are so great that all one can say in the most favourable case is that K is the most important term in the expression for the refractive index, while in other cases no confirmation whatever can be drawn from this class of evidence.

3. The magnetic and electric disturbances are both at right angles to the direction of propagation of the wave and at right angles to each other. The mathematical form of the disturbance agrees with that which constitutes light in being transverse to the direction of propagation. Further, the *electric* disturbance should be perpendicular to the plane of polarisation of plane polarised light.

4. In non-conductors the disturbance should consist of electric displacements, but in conductors it should give rise both to electric displacements and electric currents by which the undulations are absorbed by the medium. Most transparent bodies, it is true, are good insulators, and all good conductors are opaque. The degree of opacity is, however, far from being proportional to the conductivity.

5. But, perhaps, the most important criterion of all is the one relating to the very existence itself of a medium. Such a test lies in the *time* element involved in transmission from point to point. Since energy is transmitted from a luminous body, as the source, to another body which may absorb it, then plainly if time is required for the transmission, the energy must reside in the medium by which the transmission is effected during the interval between the emission and the absorption. In the emission theory the light corpuscles are the receptacles of the energy and carry it with them in their flight. According to the undulatory theory the medium filling all space is the receptacle of the energy and passes it along from point to point by the action of contiguous parts.

Foucault's *experimentum crucis* proved the emission theory untenable. Roemer's observation of the retardation of the eclipses of Jupiter's satellites, when the earth is moving away from Jupiter, is, therefore, a confirmation of the undulatory theory of light and, in consequence, a demonstration of the existence of the luminiferous ether.

At this point the history of the nature of electrical action touches upon the third period.

The period upon which we have just entered may not inappropriately be called the period of confirmation. Nothing further appears to be necessary for the complete demonstration and establishment of the electro-magnetic theory of light. The noteworthy experiments of Prof. Hertz, of Carlsruhe, are known to all. Rightly conceiving that the reality of electro-magnetic waves would be best established by the same experiments which would also establish the fundamental identity of such undulations with those of light, he had recourse to the principle of resonance or sympathetic vibrations for the detection of these long-period waves. By a device no less remarkable for its simplicity than its effectiveness, he produced electrical oscillations of such rapidity that the waves in the surrounding region were short enough to be measured. This he accomplished by attaching to the secondary terminals of an induction coil two rectangular sheets of metal each supplied with a short, stout wire, ending in a small ball. The balls were brought near each other and the discharges of the coil took place between them. Under these conditions the discharge is oscillatory, and the period may be calculated by the formula of Sir Wm. Thomson, published in 1853.*

The receiving apparatus is also of the simplest design, consisting ordinarily of a circle of wire, interrupted at a point with an adjustable opening, and of such dimensions that the waves passing through the circle may set up electrical oscillations in it, synchronising with those of the transmitting apparatus. The passage of sparks across the narrow opening of the circle indicates an electrical flow; and the necessity of adjusting the size of the circle in order to obtain this flow proves that the forces acting are periodic. The receiving apparatus must in fact be tuned so that the period of an electrical oscillation in it shall correspond with the external impulses absorbed. The intensity of the electric and magnetic disturbances is indicated by the relative length of sparks obtainable.

Equipped with this apparatus, which was installed in a large lecture hall, Hertz found not only that his tuned receiver responded to the impulses of the transmitter in the precise manner pointed out by theory, but that the sparks showed a series of maximum and minimum values recurring in periodic order as the receiver was carried further away from the source of the disturbances. The astounding fact was thus brought out that these electro-magnetic waves were reflected from the thick wall of the room, and that the combination of the direct and reflected systems produced stationary waves with loops and nodes that could be traced out by the responsive circle of wire. In this manner wave-lengths were measured down to 60 cms., and the *time element* was experimentally detected in the propagation of electrostatic and electro-dynamic induction. It was demonstrated that the disturbances producing the waves are at right angles to the direction of propagation, as Maxwell predicted, and as interference phenomena show them to be in light. Hertz has also found an electro-dynamic shadow cast by an iron post; he has verified the laws of reflection from plane and concave metallic reflectors, and has shown that electric waves suffer polarisation and refraction in a manner exactly analogous to light. Prof. Fitzgerald, of Dublin, has added another confirmation of Maxwell's doctrine, demonstrating that the *electric* disturbance is perpendicular to the plane of polarisation as Maxwell's equations require. Finally, the velocity of propagation of these electro-dynamic waves is found to be the same as the velocity of light. Thus, not only have all of Maxwell's criteria except the second abundantly confirmed the judgment of the great physicist, but other proofs have been added. Electro-magnetic waves are therefore not merely like light, but they are light. Or, perhaps, to speak more exactly, all radiant energy is transmitted as electro-magnetic waves in the luminiferous ether. Electricity has thus annexed the entire domain of light and radiant heat; and, as Prof. Lodge says, "has become a truly imperial realm." The difference of wave length in the three classes of phenomena is not a fundamental one. Increase the rate of the electrical oscillations a million fold in Hertz's experiments and the waves would not merely resemble light—they would be light. A wire through which such oscillations are surging back and forth would glow with light. Even the long heat waves would be absent, and only those producing the sensations of light and colour would remain.

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* Math. and Phys. Papers, Vol. I., p. 540.

It will be observed that the oscillations of an electric discharge constitute the point of departure for the admirable researches of Hertz; and it is a matter in which we may modestly take a bit of national pride that the first case of electric oscillations was discovered by an American physicist. The oscillatory character of the Leyden jar discharge was demonstrated by Joseph Henry in 1832 by means of the magnetic effects produced in small steel needles. It was not until 21 years later that Sir Wm. Thomson published the complete mathematical theory of such oscillations. They have since been observed directly by means of a rotating mirror. Dr. Oliver Lodge has lately shown that they rotate the plane of polarisation of light in one direction and then in the other as they surge back and forth. He has also reduced the number of oscillations from several millions per second to a few hundred by increasing the capacity and the self-induction. The discharge then vibrates within the limits of audibility and produces a musical note.

The well-known experiment of Henry, in which he observed an induction current in a wire stretched parallel to and distant 30 feet from one which served to discharge a Leyden jar is now seen to have been a case of resonance—that is, the absorption of electric waves by a conductor, producing currents therein. And it is an evidence of the great genius of Henry that he saw, somewhat dimly it may be, but still with a certain degree of rational apprehension, that the induction was transmitted across the intervening space with a velocity comparable only to that of light. He had perchance the divine touch of genius necessary for the great discovery of electro-magnetic waves coursing through the ether; but the way leading to this important physical fact had not then been sufficiently prepared, and its discovery was impossible.

Waves similar to those from a Leyden jar discharge, but of longer period, are sent out from a wire conveying alternating currents. We must conceive of such a wire, not simply as affected internally or even superficially by the electric energy surging through it, but as the source from which pulsate outward through the limitless ether, great waves of electro-magnetic disturbance. For 300 complete alternations per second these waves are a million metres, or over 600 miles in length. They present a marked contrast with the waves corresponding to the D lines of the spectrum, which are only about one five-millionth of a millimetre long.

These long waves from an alternating current represent energy. Through space it is conveyed with the velocity of light, and through other non-conductors or dielectrics with a smaller velocity precisely as in the case of the radiant energy of light or heat. Henceforth the complete equation for the distribution of energy by means of alternating currents must include a term to express the radiation from the circuit. It may, indeed, be found that this term represents no inconsiderable part of the energy communicated to the wire in the case of very rapid alternations.

Thus we see that the ether plays a magnificent *rôle* in what may be called its dynamic relation to electric displacements. In its capacity as a reservoir of static or potential energy, its agency has been better understood for a considerable period. When a continuous current begins to flow through a closed circuit, a single wave travels out from the conductor; and during its progress, while the current is approaching its constant value, the enclosing ether is assuming its condition of static repose under stress. The whole ether, extending indefinitely outward from the conductor, is profoundly modified. We know how to map out the circular lines of force about it by means of iron filings; but the iron serves only to show what has already taken place in the ether before the filings are brought into the field. Every little iron particle becomes a magnet, with all the north-seeking poles stretching in one direction round the wire, and all the south-seeking poles in the other. What the mechanism of the stress, or the motion in the ether to produce these effects may be, we do not know; but we do know that these lines of force are all subject to a tension tending to shorten them, and that they are mutually repellant laterally. When a current is sent through a conductor, the ether is expanded in concentric cylindrical layers about any straight portions of the circuit, and becomes the reservoir of potential energy. As soon as the current, which maintains this state of tension, ceases to flow, the stretched ether collapses upon the conductor, yielding up its energy in the form of self-induction. If a steady current is conceived as the setting up and breaking down of a static difference of potential energy at infinitesimal intervals of time, then the energy transmitted may depend upon a similar formation and decay of the static stress in the encompassing ether. The conductor is but the core of an electro-magnetic disturbance in the surrounding medium, and it may be that the enormous energy which a small copper wire can apparently convey is in reality transmitted by the invisible medium.

From this brief review of the theory of electric action, it will be quite evident that henceforth the language applied to electrical phenomena must always include the luminiferous ether as a prominent term. The experiments of Hertz have made it impossible to explain electrical facts without taking this invisible medium into account. There is no such thing as electric or magnetic action at a distance. The ether is always an essential part of that complex system, the interactions of which manifest themselves as electric or magnetic phenomena.

As the ear responds to the slow oscillations of an electric discharge through the intermediate agency of heat, so the eye of the mind responds to those more rapid oscillations, the existence of which has been demonstrated by experiment. No less clearly does the magnetic field appear as a system of lines of stress in the ambient ether. Definiteness has taken the place of the metaphysical speculations of earlier times. Complete ignorance has, at least, been superseded by half knowledge. We may not yet affirm with Edlund that the ether *is* electricity, but we are doubtless nearer a solution of this old problem than ever before.

The discord is vanishing slowly,
  And melts in the dominant tone.
And they that have heard it can never
  Return to confusion again,
Their voices are music for ever,
  And join in the mystical strain.

The Westinghouse Company.—This company has decided to build a branch works in England, which will probably be situate in the neighbourhood of York Road adjoining the Westinghouse Air Brake Works.

ELECTRICAL SURGINGS—AN EXPERIMENT.*

By Prof. JOHN E. DAVIES.

IN the discussion of John B. Verity's paper on "Underground Conduits," read before the Institution of Electrical Engineers on the 11th of April, the following remarks of the Chairman, Prof. Ayrton, attracted my attention, in consequence of a peculiar experience of mine some time ago while testing the potential of a 50 arc light dynamo carrying its full load. Among other things, Prof. Ayrton said :—"The question of the puncturing of insulated cables used for electric lighting is an extremely important one, and one which I think has not had sufficient attention given to it. It has been assumed that the electromotive force that the electric light cable will work at, is the electromotive force produced by the dynamo, and no more ; but, as Mr. Verity points out quite rightly in his paper, there is the probability of a very much higher electromotive force being brought to bear on cables used for electric lighting, in consequence of self-induction—a subject which will come before us in another way at our next meeting, when Prof. Oliver Lodge is to give us a paper on lightning conductors. The surging backward and forward that he has so ably drawn attention to, that you have in certain cases in electrical conductors, produces an electromotive force infinitely greater than you would expect. A case was brought to my notice the other day of a somewhat extraordinary character. Two people were walking together in the Inventions Exhibition, along a court where there were a good many electric wires. They were several feet away from the wires, which were overhead. They were walking on wood, and they both say that they simultaneously got a sharp shock. Of course, from our old point of view, we should have said that it was quite impossible ; they could not have received a spark of several feet with a potential difference of even a few thousand volts. At the same time, you have their evidence that they independently felt a shock at a certain moment, and said immediately to one another, 'I felt a shock.' They applied to the people in authority, but of course could get no information. Now, with the illustrations that we have had recently shown us by Dr. Lodge at the Royal Institution, it does not seem improbable that you may have potential differences set up in wires far greater than the potential difference that the dynamo can produce, due to the sudden stopping of the current ; for example, whether you may be working at 100 or 1,000 volts, you may have 10,000 volts, or even more, produced. I think that may explain the breakdown of some of these cables."

For certain reasons, though with some misgivings, I determined some time ago to apply one of Sir William Thomson's graded voltmeters to the measurement of the potential difference of a 50 arc light dynamo under full load. Being apprehensive, I examined the instrument with great care, even going so far as to take off the rounded end block and examine minutely the small block of hard rubber to which the copper spring clips are screwed. Everything was apparently all right ; but for precaution I discarded the twisted leads sent with the instrument, which showed some signs of wear at one point, and used instead gutta-percha coated wires widely separated. On closing the key there was a loud snap, a tremendous flash, and the experiment was over. The last mark on the graduated scale of the voltmeter indicated $\frac{1}{16}$th of a division per volt, in a dyne field ; and I had on an accessory magnet which brought the field up to more than 10 dynes, thus making each division of the divided arc of the voltmeter equal to about 160 volts ; and as the instrument could be read to 40 and 50 divisions, and the scale was even longer than the $\frac{1}{16}$th mark, I ought to have been able to measure to at least 6,400 volts, and much more, unless the graduations of the instrument were meaningless. Moreover, the instrument had in the lower parts of its scale been calibrated by me and found correct as marked, and the field of the controlling magnet was essentially what it was marked. This I had previously determined with some care.

On examining the instrument carefully after the experiment I could see nothing wrong ; the minute terminals of the coil, where visible, were intact (the whole coil has a resistance of nearly 9,000 ohms) ; even the delicate solderings of the ends of these wires to the copper clips were apparently the same as ever. An ordinary current went freely through the coil along the very circuit where the current of large potential had just refused to go. A slight discoloration of the wood near the end of the hard rubber block led me to very carefullly take out all the little screws running into it. And here I found the trouble. The ends of these screws came to within about $\frac{1}{16}$th of an inch of each other in the solid hard rubber ; but in the case of one pair, either the hole bored for the reception of one of the screws had been carried clear through the hard rubber block, thus leaving an air space of $\frac{1}{16}$th of an inch between the screw ends, or else some other defect of the material, or excess of length of the screws, had enabled the electricity to work its way through this way and form a temporary arc. Luckily I had used for one of the gutta-percha coated leads a quite small wire, which fused at the dynamo, or the consequences might have been more serious. The rubber had either been perforated at this place, or what is more likely, a spark had leaped across air. Now, taking the voltage of the dynamo at 2,800, or even 3,000, it is not likely that this would have occurred, save for the sudden diversion of the electricity from its regular channel into this side path—the "electrical surging," as Dr. Oliver Lodge so happily terms it. Another noteworthy point is the evident "throttling" effects of the self-induction of the voltmeter coil. Rather than overcome this self-induction, the sudden rush of the current, like a huge volume of water under tremendous pressure approaching a long, tortuous, and narrow channel, preferred a side leap rather than enter the confined spaces of the wire coil.

I have for years felt that a sudden charging or discharging of a piece of apparatus, or circuit, was a very different thing from the gradual doing of the same ; just as one can bear without injury a very heavy load placed gradually upon him, while a far lighter one suddenly applied may be destructive. The beautiful experiments of Dr. Lodge upon the differences between the striking effects of charges suddenly or gradually applied are a demonstration of the reality of this difference in so subtle a medium as the ether, and his calculations show us what differences to expect. As to the practical bearings of the above experiment, it is pretty evident that no matter what the graduations of the instruments might lead one to anticipate, it is not safe to apply them to dynamos carrying heavy currents under these high voltages. A previous test upon the same dynamo with Sir W. Thomson's electrostatic voltmeter had given good results. The only drawbacks to this beautiful instrument are the long time required for the needle to settle to its final reading, the uncertainty of its division values especially in the lower part of the scale, and the difficulty of accurately calibrating it. If one reads the description of it in Gray's "Absolute Electrical Measurements," or Rankin Kennedy's "Alternating Current Transformers," or Swinburne's "Practical Electrical Measurements," and then compare the figures given for the values of the weights required for 50, 100 and 200 volts per division, as given in Sir W. Thomson's latest circulars, he will be puzzled by strange discrepancies, as the figures are entirely different. My own weights are different from either or all of these—the instrument being one of the earlier ones sent out from the Glasgow laboratory—being in fact kindly selected and calibrated for use by Sir William himself. The only way to make reliable measurements with one of these instruments which one may purchase at random is to calibrate it for one's self ; and this I have found it no easy matter to do for want of other standards of high potential whose value is absolutely and independently known, which one can compare it with.

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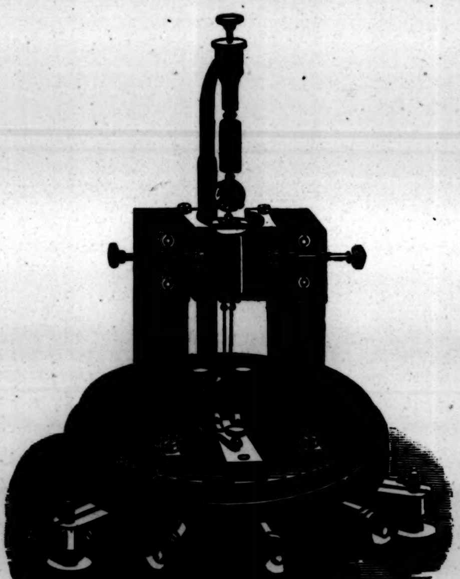
* *Western Electrician.*

It is a great pity also that, even though the cost would have been slightly enhanced thereby, the bearings on which the steel knife edge rests are not agate mounted. It seems ridiculous almost to make the axle a knife edge of apparently hardened steel while the surface on which it rides is merely of soft brass. An agate mounting would surely increase the sensitiveness of the instrument as well as make its indications more reliable.

DEPREZ-D'ARSONVAL DIFFERENTIAL GALVANOMETER.

THE value of the Deprez-d'Arsonval galvanometer is beyond dispute. Thanks to its dead-beat action which allows of rapid readings, and to the slight influence which neighbouring bodies exercise on it, it has rapidly taken a first place in industrial laboratories, and it tends to supplant the ordinary needle galvanometer for measurements of precision.

The great number of improvements of detail which have been made in the instrument since it was first brought out have very considerably extended the range of the apparatus. M. Ledeboer has himself described an arrangement carried ont by M. Carpentier with the view of rendering the instrument differential and useful for the purpose of numerous methods of measuring resistances based upon the compensation of the magnetic effects of two currents. In this arrangement two bobbins are wound parallel on the movable frame of the galvanometer, the ends of the coils being connected to four terminals through a double bifilar suspension.



The construction of such an instrument is found to be difficult, for though it is easy to give to the circuit of the two bobbins equal resistances and the same number of turns, it is extremely difficult to produce exact equilibrium by the differential effect of two currents acting in a magnetic field the lines of force of which are very irregularly distributed.

It is true that the two bobbins can be wound with a double wire as is often done in the case of differential electromagnets, but the necessity of reducing as much as possible the size of the movable frame prevents the employment of a thick covering to the wire, and there is a consequent liability of contacts between the two wires.

In order to facilitate the construction and the adjustment of the instrument, M. Eric Gérard arms the poles of the magnet with two armatures which, instead of being fixed as in the ordinary apparatus, are movable about vertical hinges, and can be approached or withdrawn obliquely to a central bar of soft iron by means of two screws of very low pitch.

By this means the distribution of the lines of force of the field can be regulated at will and it is easy to produce magnetic equilibrium of the currents in the two bobbins.

In the apparatus (shown by the figure) which has been constructed by MM. Emile Gerard et Cie., the two regulating screws are represented on the back face of the magnet. The double bobbin is supported by a cocoon fibre which is axial to a bronze spiral spring forming a connection common to the two circuits. The other connections are made below by two wires. It must be evident that if the two ends of each bobbin require to be available, the upper spiral spring must be replaced by a two wire suspension, though at the cost of diminished sensitiveness.

BRADFORD CORPORATION ELECTRICITY SUPPLY.

THE electric lighting station was formally opened by the Mayor (Alderman W. Moulson) on Friday last. The installation is the continuous current system; and is intended for the supply of lighting, motive power, storage, and for other purposes.

It is proposed, in the first instance, to supply that portion of the centre of the town which comprises Market Street, Kirkgate, and the streets in the immediate vicinity thereof.

The mains, lead encased, and with suitable outer protection, are laid underground in all the above streets. The cables are placed directly in the earth, generally under the causeways or pavement, and where crossing the streets a flag-topped brick culvert protects the cables from the heavy traffic.

The central station is situated at Bolton Road, a short distance outside the district of supply. The buildings, when fully completed, will be capable of containing considerably more generating plant than is at present placed there.

The present generating plant consists of three Lancashire mild-steel boilers (28′ × 7′) of 180 H.P. each; three steam engines, of the inverted vertical type, of 150 H.P. each, and working at 120 lbs. steam pressure. Two of these engines being made by Willans and Robinson, Limited, of Thames Ditton; the third one being by Marshall, Sons and Co., Limited, of Gainsboro'. Each of these engines is coupled to and drives direct a Siemens's dynamo, capable of developing 120 electrical H.P. (90 kilo-watts). Each of these dynamos delivers its current to a conductor common to the three; whence it is supplied to the various feeding mains.

These feeding mains, at present four in number, deliver the current at their outer extremity to four feeding centres situated at different points in the town; suitable controlling apparatus being placed at the central station to ensure a uniform electrical pressure of delivery at the feeding centres.

From these various feeding centres extends a network of distributing cables connecting together the various streets, and the several feeding centres. To these distributing mains the houses are directly connected.

About ten miles of cable are comprised in these feeding and distributing mains, exclusive of the connections to the various houses.

A number of street boxes and other forms of junctions assist in forming the branches in the several streets and help to complete this system of distribution.

The branch service line to each house ends in a terminal box and an electricity meter to which are connected the wires of the private lighting of each premises. The meters at present in use are those known as the "Aron," the "Hookham," and the "Edison," the particular meter supplied to each premises being in accordance with the quantity of current required.

The prices at which the Corporation propose to supply the electric current is 5d. per Board of Trade unit; or about double the present price of gas in the borough.

In consequence of the proximity of the district of supply to the generating station the current is supplied at present, direct at the low pressure at which the houses are required to be supplied by the Board of Trade. But later on, as more distant districts have to be supplied, the "feeding mains," or carriers, will be put upon high pressure; arrangements being made in the laying of the mains to enable this to be done.

The buildings have been constructed by Mr. Wm. Johnson, of Bradford; the boilers by Messrs. Holdsworth and Sons, also of Bradford; while the entire of the electric plant, including dynamos, cables, electric instruments and appliances of all kinds for the regulation of the current, have been constructed and laid by Messrs. Siemens Bros. and Co., Limited, of London. The installation has been designed for the Corporation, and superintended during erection by their electrical engineer, Mr. James N. Shoolbred, Mem. Inst. C.E., of Westminster.

THE BRITISH ASSOCIATION.

SERIES ELECTRICAL TRACTION.

(*Northfleet Tramways.*)

(*Read in Section G, September* 16*th*, 1889.)

By EDWARD MANVILLE, M.I.E.E.

THE expenses of horsing a tramway form such a serious proportion of the total working expense, that any cheaper effective method of propulsion will naturally be gladly received by the various companies.

Steam and compressed air have been extensively tried, and although in some cases their expense has compared favourably with horsing, the machinery used is so cumbersome, and the nuisance so great, that even companies who have incurred the expense of abandoning horses in favour of steam are seriously meditating the adoption of electricity.

The cable systems have met with considerable success in the United States, and have achieved some measure of success in the United Kingdom; but the conditions under which a cable line can be operated economically are tremendously heavy traffics, such as do not exist in the United Kingdom, but do in the United States, where, as is well known, tram cars are practically the only available street conveyances.

Many leading authorities in tramway administration who have tested and considered the various methods of tram car propulsion, have of late publicly expressed their confidence in the great suitability and economy of electricity for the purpose. The subject is therefore one of peculiar significance, not only to shareholders in the direction of increased dividends, but also to the large body of the public using this popular method of conveyance from the point of view of reduced fares.

It is obvious that in systems of mechanical propulsion requiring the distribution of power over many miles of line, that the efficiency of the distribution will be better as the number of generating stations is diminished, and that the maximum economy is attained when all the power for a complete system is developed at one only.

To distribute electrical power economically from one generating station over distances such as are covered by tramway systems of any extent, it is essential that high tension currents should be employed, so as to minimise the loss of power in the conductors. Now, if the full tension of such currents were applied to the driving motor on each car, grave difficulties would present themselves in manipulation and in preserving the motor from injury. By the series system, however, it is possible by running the motors in series—as the name indicates—to attain the maximum ease of manipulation together with perfect safety to the motor. This was recognised at an early stage by the late Prof. Fleeming Jenkin and Profs. Ayrton and Perry, and the first electric locomotives ever run in series were used by them in connection with telpherage.

The subject of electrical traction reached such a degree of prominence in this country that early last year steps were taken to demonstrate the practicability of running electric motors for tramcars in series with each other, and an electrical tramway on the series system was equipped and put into operation at Northfleet.

The essential parts of an electrical tramway line in which the motors are run in series are: an electric generator producing a current of constant quantity and an electrical pressure varying continually, according to the total work being done by the whole of the motors together; the conductor taking the current from the generator to the motors, provided with automatic switches of such a character as to enable the continuity of the conductor to be broken as long as the motor is in electrical contact with the open ends of the conductor, and to be closed as soon as the motor, in passing away, ceases to be in contact with the ends of the conductor.

This operation must be performed without disturbing the metallic continuity of the circuit, and without short circuiting the motor.

The generator used at Northfleet is one of Statter's patent constant current dynamos, in which type of machine the E.M.F. is varied by the alteration of the position of the brushes on the commutator; this is effected by an electrical regulator. The current, after being generated in the dynamo, before going to line, passes through a solenoid containing a moving soft iron core. The position of this core regulates the position of the brushes by means of a double ratchet working on a wheel with two sets of teeth on its periphery, which wheel moves the brushes through a gear. The double ratchet is kept rapidly moving too-and-fro by an eccentric working off the dynamo shaft through a reducing gear. So long as the current is of the proper quantity, the position of the core is such that the ratchet does not engage with either of the two sets of teeth on the wheel, but when the current rises or falls the position of the core is altered, so as to cause the ratchet to engage with one or other of the sets of teeth, when the position of the brushes is rapidly altered to adjust the current quantity. The pole pieces of the dynamo are so shaped as to reduce the "sparking" that might be supposed to result from the variation of the lead of the brushes so much as to make it practically negligible. The E.M.F. is varied from a few volts to upwards of 400. The current, after passing through the regulator, goes to a highly-insulated cable, reaching the whole length of the line. The cable is cut at distances of 21 feet along the line, and the ends of it are led into terminals connected with the opposite faces of a "spring-jack," which is at the same time the automatic switch and contact point from which the current is collected. From the last "spring-jack" at the end of the line, a return cable, with its insulation unbroken, is brought back to the other terminal of the generator, owing to the line at Northfleet being a single track.

The "spring-jack" just referred to consists of a pair of glased eathenware blocks, 14 inches by 3 inches by 4 inches. To each block is attached, by means of a double spiral spring, a gun-metal casting, curved at the ends, but flat in the centre. The springs are of sufficient strength to press the two castings together with a force of 6 lbs. Under the car, and for its entire length, is the collector, or "arrow," which consists of two thicknesses of India-rubber belting, each having a broad brass strip rivetted to it for nearly its entire length. The nose of the "arrow" at each end is shod with wrought iron, brought to a knife edge, so as to easily force its way between the two faces of the "spring-jack," which automatically close after its passage. The maximum thickness of the "arrow" is 1 inch, which is consequently the extent to which the gun-metal cheeks are separated. The conductor on each side of the "arrow" is lapped round one end, and an insulated space is left, slightly greater than the surface of contact of the "spring-jack" near the extreme ends on opposite sides. By these gaps, the passage of the collector, from one "spring-jack" to another, is effected without short-circuiting the motor. It will be readily seen from this that at no moment is the current cut off from the motor, or at no moment is the motor short-circuited. In fact, the ammeter carried on each car shows the constant value of the current, without any variation.

The conductor on each side of the arrow is connected by an insulated cable with the motor carried on the car. On each platform of the car are two strong switches. One of these serves to reverse the direction of the rotation of the armature by altering the connections between the field magnets and the armature, the other regulating the power of the motor by shunting more or less current from the field magnets. Three speeds are provided for, and the stopping of the car is brought about by completely short-circuiting the field magnet, still allowing the current to pass through the armature.

The motors are run at 400 revolutions per minute, delivering at this speed, when the field magnets are fully excited, 15 H.P. on the brake. This slow speed was adopted to do away with intermediate gearing between the motor shaft and the car shaft, which has up to this time been the usual practice.

At Northfleet the motor pinion gears direct with a spur wheel on the car shaft in the ratio of 1—4½. The gearing is double helical, with a view to noiseless running, and the practical working of this gear is most satisfactory.

The motors are mounted in a way now generally adopted in the United States, one end being supported by two half bearings on the driving shaft of the car, the other end being suspended by a spiral spring from a stout beam across the car body.

The motors are of the Elwell-Parker type, and the field magnets are connected in series to the armature. One of the cars is lighted electrically by means of low resistance Bernstein lamps. Three accumulator cells, of the tramway type of the Electrical Power Storage Company, are inserted in the main circuit, and five lamps, of 10 ampères each and 6·5 volts, are run in parallel off the accumulators. The accumulators themselves, however, are not discharged; they only serve as potential reducers, the whole of the main current going through the lamps. Should one of the lamps break, the remainder are slightly more brightly incandesced, and the current due to the broken lamp passes through the accumulator. A two-way switch enables the accumulator to be taken in or out of the main circuit, and the accumulators are large enough to run all the lamps without assistance from the main current, should it be requisite.

The generator is driven by a Robey compound under-type engine of 10 H.P. (nominal), with a locomotive boiler over it.

The appearance of the tramway on the road surface is in all respects similar to that of an ordinary tramway, the conduit through which the "arrow" travels, and in which the "spring-jacks" or contact points are situated, being formed beneath one of the running rails. This running rail differs from the ordinary tramway rail, inasmuch as the tread and guard portions consist of two separate and independent rails, having a narrow slot ⅛-inch in width between them, through which the mechanical connections between the "arrow" travelling in the slot and the car body are situated. By this means any further interference with the surface of the road than that which is common to all tramway systems is avoided. The tube is 8 inches in width, the bottom being 13 inches below the surface of the road, this being an exceptionally small conduit as compared with the conduits commonly in use for cable tramways, such conduits having the further disadvantage of necessitating two central rails, owing to their being situated in the middle of the track. The rails are supported by means of cast-iron chairs or yokes, to which they are securely bolted. These yokes are placed at intervals of about 4 feet, excepting at the rail-joints, where they are closer together, the sides and bottom of the tube between these yokes being formed of Portland cement concrete. The rails are made in 21 feet lengths, corresponding with the distance apart of the "spring-jacks," and at each rail-joint a special chamber is formed, having a convenient removable lid, by means of which access is obtained to the "spring-jacks." The yokes on either side of the joints are similar to the ordinary yokes, excepting that they are provided with recesses to receive the stoneware separating blocks, to which the "spring-jack" cheeks are attached. The rail-joints themselves are fished in the ordinary manner. The centre of the tube is placed somewhat inside the track, in order that the "arrow," when travelling, shall not be directly underneath the slot, so as to avoid the danger of water from the road surface in wet weather falling directly on the "arrow," and also with a view to protecting the "spring-jack" cheeks themselves in a similar manner. The roof of the conduit between the yokes is formed by a Z-shaped roof plate. The cable joining the "spring-jacks" is led, in an independent 3-inch earthenware pipe, running from chamber to chamber, and in this tube also is laid the return cable. Some special construction of points and crossings is necessitated, owing to the junction or crossing of the two tubes underneath the track, which involves a considerable projection of unsupported tongue. In order to secure the safety of ordinary traffic passing over these tongues, a tumbler or rocking device has been provided, which forms a support for the toe of the tongue when the car is not over the point, but which, during the passage of the car, is pressed aside by means of the "arrow" shanks, which will be referred to hereafter.

Owing to the narrowness of a portion of the road, the Board of Trade required that the line in this part should be constructed in a manner technically known as a "double-single" line; that is to say, with three rails, so as while keeping the tramway cars on the proper side of the road in the direction they are travelling, and thus allowing clearance for ordinary road traffic, to prohibit the possibility of two tramway cars passing each other in this narrow part. At this portion of the line two of the rails had to be formed with conduits, the third being an ordinary tramway rail. Some special forms of construction, as regards points and crossings, were necessitated in this portion of the road, but space does not permit of a full description being given of these and many other mechanical contrivances which had to be provided. They, however, are arranged so as under all circumstances to automatically guide the car with its "arrow" in the right direction. Drain pipes are provided for the removal of water from the tube.

The "arrow" or collector referred to before is supported by means of five shanks, these shanks being attached to cast iron "shoes" or "skates," which travel on the rail, these being drawn by means of chains attached to the car body, and connected by light tie-bars above the rail level. The leading shank in either direction is provided with a plough or stone-thrower, for the purpose of removing any obstruction which may be met with in the slot. The insulated cables connecting the conductors on the "arrow" with the motor are led up through recesses in two of the shanks and skates. The mechanical details of the system were designed by Mr. Joseph Kincaid, and carried out for him under the supervision of Mr. J. S. Waller.

It may be well to point out, in series running, that, owing to the employment of a current of constant value, it is impossible for the most inexperienced car driver to damage his motor by either too rapid starting or by reversing whilst running; indeed, it is a positive advantage when descending a hill to check the speed of the car by altering the field connections so that the armature tends to revolve in the opposite direction to that in which the car is travelling, as the power that would otherwise be lost in braking the car is actually added to that produced by the generator, and thus large systems, with many cars and varying gradients, would appreciably reduce the total power required to be generated, and the consequent consumption of coal.

These advantages, combined with the efficiency of distribution as regards the percentage of power lost in the conductors, with, at the same time, but a low difference of potential at the terminals of each individual motor, may be regarded as the main advantages of series running.

[The drawings which were employed to illustrate this paper were the same as those used by the ELECTRICAL REVIEW and other technical journals when describing the opening of the Northfleet line.]

ON THE RELATIVE EFFECTS OF STEADY AND ALTERNATE CURRENTS ON DIFFERENT CONDUCTORS.*

By WILLIAM HENRY PREECE, F.R.S.

1. Sir William Thomson, at the Bath meeting of the British Association, startled the electrical world by asserting that alternate currents entered a distance of only about 3 millimetres into the heart of a thick, round, copper conductor when the frequency was 150. This "Diffusion Law," as he called it, is based on the assumption that a current starts at the surface of the conductor and works its way radially inwards. It is dependent on the coefficient of self-induction and on the frequency—that is, on the number of complete alternations of positive and negative currents transmitted per second.

2. As this law has a most important bearing on the commercial value of systems of distribution dependent on alternate currents, it becomes most desirable to study the question practically. The verification of the law is almost beyond the reach of experiment. It occurred to me, however, that if we took conductors of different materials, such as iron, copper, lead, and platinoid, of easily measurable lengths and of convenient sectional areas, and transmitted through them measurable and variable currents, both alternate and direct, approximately similar to those used in practice, we should be able to study the question by observing the changes of temperature in the conductors, and we should at least observe any difference, if such existed, in the total expenditure of energy in the conductors under these different circumstances. Any addition or diminution of energy expended would give some indication of the operation of the law of diffusion in comparatively small conductors without, however, determining the actual distribution of current density.

3. The Eastbourne Electric Light Company placed their machinery at my disposal. Messrs. Bolton and Son supplied me with copper, Messrs. Frederick Smith & Co. with iron, Messrs. John Fowler & Co. with lead, the London Electric Wire Company with platinoid, and Messrs. Elwell Parker & Co. with accumulators and a specially-made converter. I was fortunate in securing the assistance of Mr. Lowrie, the engineer to the Electric Light Company, and of Mr. Gay, the assistant engineer, who constructed the apparatus and took and recorded the observations. The experiments were very numerous, very costly, and extended over a long period.

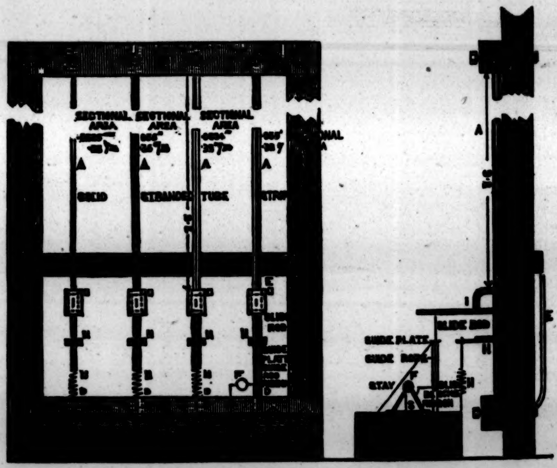


FIG. 1.

4. An extremely strong wooden frame (fig. 1) was constructed, with a stout crossbar of iron at the top, B, which not only rigidly fixed one end of the conductors, A, to be tested, but also formed a terminal block for the currents. The lower end of the conductors dipped freely into an iron well, D, which could be filled with mercury at will by means of the tubes, E, and acted as the other terminal. Stirrups and springs, H, were fixed so as to prevent the buckling of the conductors to be tested. A length of 9 feet 8 inches (294·6 centimetres) was accurately marked off each rod, and a clamp, I, was fixed on to the conductor so as to transmit the expansion of the rod to the mirror apparatus, F, which could be slid under each rod as it was tested. The construction of this mirror arrangemeut is more fully shown in fig. 2. The mirror was deflected by the down thrust of the clamp on the rod, so that a

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* Paper read before the British Association at Newcastle-on-Tyne in Section A, September, 1889.

thin metallic ribbon, passing over a pulley on the axis of the mirror, moved it with equal increments in all parts of the scale. A spring, s, brought the mirror back to zero. It reflected a ray of light from the oxyhydrogen lamp H, 20 feet 10 inches long (635 centimetres), on to the curved screen N, upon which a scale was drawn such that 1 inch equalled every one-thousanth of an inch expansion of the conductor A. The scale formed an arc of a circle, having the mirror as its centre.

The connections for the transmission of currents are shown by fig. 2. A was an ammeter—one of Sir William Thomson's recent hecto-ampère balances—and B a voltmeter, reading to a hundredth of a volt, specially constructed by Messrs. Ayrton and Perry on their latest hot-wire method. C were 15 secondary cells for the production of steady currents, and D was a Lowrie-Hall converter to transform the high-tension currents (2,000 volts) of the electric light station to the low tension currents (4 volts) required for measurement. The range of variation of frequency was not very great, nor so great as I should have wished. It would have required other converters to have extended the range, for with the converter having the ratio 2,000/4 any reduction in frequency lowered the E.M.F. at the two ends of the conductors, and it was impossible to get the requisite current through the conductors. E was the alternate current switch, and F that for continuous currents. L was a resistance of platinoid used to equalise the E.M.F. of the accumulators and converter. M was a variable resistance used to adjust the current.

A.—Copper.

Material.					Temperature.				Elongation.				Current.					Dynamo.	
Description.	Section.		Length.		Air.		Metal.		Time.		Extreme elongation.		—	Time on.	Amp.	Density.		Speed.	Fre-quency.
	Sq. in.	Sq. cm.	In.	Cm.	F.°	C.°	F.°	C.°	Started.	Stopped.	In.	Cm.				Sq. in.	Sq. cm		
							maxi	mum.	h. m.	h. m.				min.					
* Round rod	·0589	·38	116	294·6	48	8·8	136	57·7	8 2	8 40	·104	·264	Steady	38	200	3395	526	...	...
	·0589	·38	116	294·6	48	8·8	136	57·7	8 42	8 45	·103	·261	Alternating	3	200	3395	526	404	107·73
Tube	·0604	·39	116	294·6	46	7·7	115	46·1	3 43	4 6	·081	·205	Steady	23	200	3311	513	...	...
	·0604	·39	116	294·6	46	7·7	115	46·1	4 6	4 8	·081	·205	Alternating	2	200	3311	513	404	107·73
Tube	·0604	·39	116	294·6	48	8·8	118	47·6	6 39	7 0	·0825	·209	Steady	21	200	3311	513	...	...
	·0604	·39	116	294·6	48	8·8	118	47·6	7 0	7 2	·0825	·209	Alternating	2	200	3311	513	404	107·73
† Stranded cable	·056	·36	116	294·6	48	8·8	133	56·1	7 16	7 50	·0995	·252	Steady	34	200	3571	555	...	...
	·056	·36	116	294·6	48	8·8	133	56·1	7 50	7 52	·099	·252	Alternating	2	200	3571	555	404	107·73
Flat rod....	·059	·38	116	294·6	46	7·7	139	59·4	3 6	3 27	·109	·276	Steady	21	200	3390	526	...	...
	·059	·38	116	294·6	46	7·7	136	57·7	3 27	3 30	·105	·266	Alternating	3	200	3390	526	404	107·73
‡ Round rod	·0589	·38	116	294·6	58	14·4	149	65·	12 40	1 0	·107	·271	Alternating	20	200	3395	526	577	105·78
	·0589	·38	116	294·6	58	14·4	149	65·	1 0	1 3	·107	·271	Steady	3	200	3395	526	...	...
§ Round rod	·0589	·38	116	294·6	52	11·1	145	62·7	9 7	9 37	·109	·276	Alternating	30	200	3395	526	380	76·
	·0589	·38	116	294·6	52	11·1	145	62·7	9 37	9 40	·109	·276	Steady	3	200	3395	526	...	...
‖ Round rod	·0589	·38	116	294·6	52	11·1	145	62·7	11 57	12 26	·109	·276	Alternating	29	200	3395	526	305	61·
	·0589	·38	116	294·6	52	11·1	145	62·7	12 29	12 32	·109	·276	Steady	3	200	3395	526	...	...

* In this case the direct current was tried first, and when deflection ceased it was cut off and deflection allowed to fall to ·100; then the alternating was put on, when it rose to ·103 *only*. † 7 No. 14. ‡ Diagram No. 2. § Diagram No. 1. ‖ Diagram No. 3.

B.—Iron.

Material.					Temperature,				Elongation.				Current.					Dynamo.	
Description.	Section.		Length.		Air.		Metal.		Time.		Extreme elongation.		—	Time on.	Amp.	Density.		Speed.	Fre-quency.
	Sq. in.	Sq. cm.	In.	Cm.	F.°	C.°	F.°	C.°	Started.	Stopped.	in.	cm.				sq. in.	sq. cm.		
									h. m.	h. m.				min.					
Small round rod.	·0706	·45	116	294·6	48	8·8	182	83·3	8 53	9 20	·104	·264	Steady	27	98·9	1400	219	...	...
	·0706	·45	116	294·6	48	8·8	207	97·2	9 20	9 25	·124	·315	Alternating	5	67·8	960	150	404	107·73
Flat rod ...	·056	·361	116	294·6	49	9·4	197	91·6	9 45	10 20	·115	·292	Alternating	35	67·8	1210	187	404	107·73
	·056	·361	116	294·6	50	10·	108	42·2	10 20	10 29	·045	·114	Steady	9	67·8	1210	187	...	...
Stranded cable.	·178	1·148	116	294·6	54 to 56	12·2 to 13·3	139	59·4	7 35	8 17	·065	·165	Steady	42	177·9	1000	155	...	...
	·178	1·148	116	294·6	56	13·3	230	110·	8 17	8 32	·135§	·343	Alternating	15	177·9	1000	155	400	80·
Large round rod.	·196	1·266	116	294·6	56	13·3	230	110·	8 45	9 4	·135§	·343	Alternating	19	141·9	724	112	400	80·
	·196	1·266	116	294·6	56	13·3	125	51·6	9 4	9 40	·054	·137	Steady	36	141·9	724	112	...	...
Small round rod.	·0706*	·45	116	294·6	56 to 58	13·3 to 14·4	232	111·1	11 53	12 12	·135§	·343	Alternating	19	67·8	960	150	577	105·78
	·0706	·45	116	294·6	58	14·4	138	59·	12 15	12 28	·062	·157	Steady	13	67·8	960	150	...	...
Small round rod.	·0706†	·45	116	294·6	52	11·1	196	91·1	8 3	8 32	·109	·276	Alternating	29	67·8	960	150	380	76·
	·0706	·45	116	294·6	52	11·1	116	46·6	8 32	8 54	·05	·127	Steady	22	67·8	960	150	...	...
Small round rod.‡	·0706	·45	116	294·6	56 to 58	13·3 to 14·4	194	90·	3 26	3 47	·106	·269	Alternating	21	79·5	1126	176	305	61·
	·0706	·45	116	294·6	58	14·4	144	62·2	3 47	4 1	·067	·170	Steady	14	79·5	1126	176	...	...

* Diagram No. 1. † Diagram No. 2. ‡ The current being higher in this experiment is accounted for as follows: In the other experiments the greater number of alternations produced much greater back E.M.F., which kept the current down. In this experiment, the number of alternations being very low, the effect of self-induction was also low, and the varying resistance used to regulate the current was insufficient, consequently the current given was the lowest obtained. In the direct-current circuit there was a constant resistance besides the varying one, and it was therefore possible to keep that down in the other experiments, but, of course, in this experiment the steady current was made the same as the alternating. § Off scale.

The current density was in excess of that adopted in practice, and the currents were so adjusted that they gave a convenient reading on the scale, and they were kept constant during each experiment. All the connections were made of very massive copper.

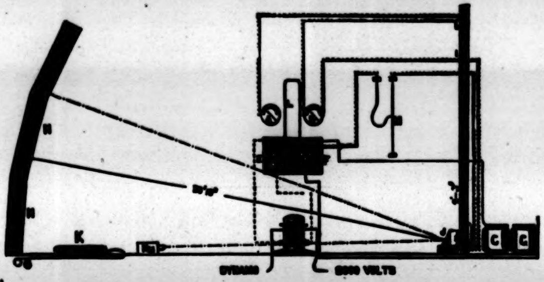

FIG. 2.

5. In the preliminary experiments that were made to determine the mode of procedure and the final form of the apparatus conductors of copper, iron, lead, and platinoid were used, but in the final experiments only iron and copper were employed. Each metal was taken of the same length and of the following forms: Round rod, flat rod, tube, and stranded cable. The various dimensions are given in the tables. The temperature was in all cases determined from the elongation of the conductor.

FIG. 3.

6. The observations were taken sometimes with steady currents and sometimes with alternating currents first. Each kind of current, after being switched on, was kept constant until all expansion ceased, after which the current was instantly changed to the reverse kind, and any change of elongation observed. Each experiment lasted from 20 minutes to half an hour. The results are tabulated on the Tables A and B, and some of the experiments plotted as curves on the diagram (fig. 3). For this latter purpose observations were taken and recorded at every minute. The abscissa is *time* in minutes, and the ordinates elongation in thousandths of an inch.

7. As regards copper, it is very clear that, whether the current were steady or alternating, the effect of heat generated in the conductors was virtually the same; but of the different forms the tube gave the best results, owing, doubtless, to the increased radiating surface.

8. The performance of the iron conductor is very decided. Here we have a large increment of heat, due clearly to reversals of circular magnetisation. Hysteresis evidently plays a most important function, and the conductor in consequence becomes a source of heat, which varies in intensity, not only with the strength of the current, but also with the frequency of the alternations.

9. The difference of behaviour between iron and copper is very marked in the sounds they emit when transmitting alternate currents. Iron vibrates mechanically, and emits loud, powerful sounds, filling the room with a roar, and increasing in intensity with the frequency. The sound of copper is very slight, and only perceptible when the ear is close to the conductor, even with the maximum current. It is only what one would expect from rapid variations in emissivity under such alternations.

This vibration, so marked in iron, has a very important bearing on the durability of the insulating material; for it is difficult to conceive any material that could stand such molecular disturbances without injury for any length of time.

10. This generation of heat in iron conductors leads to the conclusion that the fusing current for small wires would differ considerably between steady and alternate currents. All tables are made on the basis of steady currents. No. 11 iron wire, 116 millimetres (·295 centimetres) in diameter was taken.

Calculated fusing current	...	...	122	ampères.
Steady	„	... ...	120	„
Alternating	„	... ...	92	„

No difference was observed with copper.

11. The general conclusion to be drawn from these experiments is that practically no serious error has been made in the form of conductors so much used for alternating current systems, and that nothing cheaper or better has been devised than a simple stranded conductor, coated with a suitable insulating coating, and protected outside with lead, or some impervious and strong material.

They do not solve the question of the distribution of current density through the section of the conductor, but they do show that within the range of practice the total flow of energy is the same in copper conductors, whether it be urged by alternate or by steady currents.

THE PASSAGE OF ELECTRICITY THROUGH GASES.

By ARTHUR SCHUSTER.

THE author has during the last two years investigated the distribution of potential in the neighbourhood of the negative pole of a discharge of electricity through rarefied gases. Knowing the rate of fall of potential, it can be determined whether there is any bodily electrification in any part of the negative glow. It was found that the negative pole is surrounded by an atmosphere of positively electrified gaseous particles extending to the outer edge of the so-called dark space. According to the author's views, this atmosphere corresponds to the polarised layer adjoining the negative electrode in an electrolyte. The cause of the sudden difference in luminosity between the dark space and the negative glow has also been investigated, and it has been found that the negative particles projected from the negative electrode pass unhindered through the dark space, while their velocity is quickly reduced in the glow proper, the translatory energy being thus changed into energy of vibration.

THE MANUFACTURE OF THE ALLOYS OF ALUMINIUM IN THE ELECTRIC FURNACE.

By MR. J. H. DAGGER.

(*Read September 13th before Section B.*)

DEVILLE's method, modified in detail, is still the chief of the chemical processes for the production of aluminium, and is dependent upon the cost of metallic sodium. The greatest value of aluminium is, however, in its alloys, and the successful application of the intense heat of the electric arc to their production on a commercial scale marks a departure in electro-metallurgy of which we cannot over-estimate the importance, rendering it possible to produce rich alloys of this metal at half the cost of any other method, and so widening the field of their application to an extent hitherto unknown. At the works of the Cowles Co., Lockport, N.Y., U.S.A., there are in operation fourteen furnaces, the electricity for which is generated by three dynamos, capable of supplying a current of 3,000 to 3,200 ampères, and E.M.F. of 55 to 60 volts. These furnaces can produce 2,500 lbs. of aluminium bronze (10 per cent.), and 1,800 lbs. of ferro-aluminium (10 per cent.), or a total yield of 430 lbs. of contained aluminium per 24 hours. The English works of the company at Milton, Staffordshire, contain twelve furnaces, with a 500 horse-power dynamo, built by Messrs. Crompton, and said to be the largest machine in England, and probably in the world; it furnishes a current of 5,000 to 6,000 ampères, with an E.M.F. of 50 to 60 volts. The production of these works is 2,300 lbs. aluminium bronze (10 per cent.), and 1,800 lbs. ferro-aluminium (10 per cent.) per 24 hours, or 410 lbs. of contained aluminium. The furnaces are rectangular in form, and are of firebrick; into each end is built a cast iron tube, through which the carbon electrodes enter the furnace; each electrode consists of a bundle of nine carbons, each 2¼ inches diameter, attached to a head of cast iron for a ferro-aluminium furnace, and of cast copper for aluminium bronze or alloys containing copper. This head is secured to copper rods, or "leads," which can be readily connected with or disconnected from the flexible cables supplying the current. Each cable is secured to slides travelling on an omnibus bar of copper overhead, and so can be brought into position opposite the furnaces to be used. The electrodes are arranged so that it is possible, by means of a handle and screw, to advance or withdraw them from each other in the furnace. The first furnaces were lined with charcoal, but it was found that the intense heat converted it into graphite, which, being a conductor, not only meant loss of power, but the destruction of the furnace walls. This difficulty has been overcome by soaking the charcoal in lime water, and carefully drying before use; each particle of charcoal is thus coated with insulating shell of lime. Lining the furnace is the first operation; the bottom of the trough is covered with a layer of prepared charcoal, the electrodes are arranged in the furnace, and a "former," a sheet iron box without top or bottom, each end being arched to fit over the electrodes, is inserted; charcoal is then rammed into the space between it and the firebrick walls. This done, the charge of ore, mixed with coarse charcoal and the metal to be alloyed with the aluminium, in form of turnings or granules, is placed inside the iron box, after which this is carefully withdrawn; the space between the electrodes is bridged by some broken pieces of carbon, the charge is covered with coarse charcoal, and the furnace closed by a heavy cast iron cover having a hole in the centre for the escape of gases evolved during the reaction; the cover is luted so as to prevent the entrance of air. The commencing current is about 3,000 ampères, and is gradually increased to 5,000 ampères; a "run" occupies about 1½ hours. The furnace is allowed to cool; the next, ready charged, is connected with the cables, so that the process is a continuous one, the furnaces being successively charged and connected. The crude metal from the furnace is then re-melted in an ordinary reverberating furnace, a sample being taken from each run and assayed for aluminium. The nature of the reaction that takes place in the electric furnace is not very easy to ascertain; the conditions are unlike those of any other known; the reduction of the aluminium taking place in absence of air and in presence of an enormous excess of carbon, it may be assumed that, at the intense heat of the electric arc, the ore melts and gives up its oxygen to the carbon:—

$$Al_2 O_3 + 3C = 3CO + Al_2.$$

In the absence of copper, the liberated aluminium absorbs carbon, and is converted into a carbide of the metal. The escaping gas which burns at the orifice in the cover is almost entirely composed of CO. The most valuable of the alloys are those with copper. Aluminium bronze has great tensile strength. A bar containing 11·0 per cent. aluminium made by the electric furnace, and tested by the Leeds Forge Company, Limited, gave a tensile strain of 57·27 tons, or 128,400 lbs. to the square inch. One, containing 7·5 per cent. aluminium, tested by Prof. Unwin, broke under 36·78 tons = 89,743 lbs. to the square inch. In resistance to compression this alloy equals the best steel; its transverse strength, or rigidity, is about 40 times greater than ordinary brass. Its elastic limit is higher than that of mild steel, and it can be worked at a bright red heat as easily as wrought iron. Its mechanical and physical properties render it useful for every variety of metal work, its high price only having hitherto restricted its use. Its enormous strength and anti-corrodible qualities recommend it as valuable above any other alloy for propeller blades, stern and rudder frames, and for hydraulic and engineering work generally. Above 11 per cent. the alloy becomes brittle, and at 20 per cent. can be powdered readily in a mortar. The addition of small quantities of aluminium lowers the fusing point of iron, and this is utilised in the "Mitis" castings. It ensures freedom from blow-holes, increased tensile strength, and high elastic limit. Mr. Keep found that 0·1 per cent. aluminium raised the transverse breaking strength of a ½-inch bar, 12 inches long, from 379 lbs. to 545 lbs., or 44 per cent., and the resistance to impact from 239 lbs. to 254 lbs., or 6 per cent. The tensile strength of mitis castings may be as high as 27 tons per square inch, with an elongation of 20 per cent. Another alloy made in the electric furnace is silicon bronze, which, owing to its great strength and tenacity, its resistance to corrosion, combined with high electrical conductivity, is, perhaps, the best metal extant for electric light, telephone, and telegraph wires.

REVIEWS.

Papers on Alternating Currents of Electricity for the use of Students and Engineers. By T. H. BLAKESLEY, M.A. Second Edition. London: Whittaker & Co., and George Bell and Sons.

This book is nominally a second edition of a reprint of a series of papers that appeared in the *Electrician*, but it is really very much enlarged, and contains papers from the *Transactions* of the Physical Society and from the *Philosophical Magazine*, and some matter which has not appeared before.

As is well known, Mr. Blakesley originated the application of the geometrical treatment of simple periodic motion to alternating currents. This diagrammatic method of dealing with such subjects is quite common in books on dynamics or physics, but Mr. Blakesley has made very considerable developments in order to deal with the complicated problems he discusses.

We do not wish to take too one-sided a view of this book, as it is a work that must have taken considerable thought; but we cannot help feeling that the conclusions arrived at are only valuable in so far as the assumption of simple harmonic motion is warrantable. For instance, the case of a coil rotating uniformly in a uniform field does not occur in dynamo work. Mr. Blakesley says that the variation of telephonic currents, as produced in a Bell telephone, is also harmonic. This is a very bold statement. It would mean, for instance, that all musical instruments would give the same *timbre* when heard through a telephone. Thus the tones of a trumpet, a violin, or a clarionet would differ only in loudness from the soft tones of a flute, and even a harmonium would have its upper partials removed, and would sound like a musical instrument. In the middle of the book, however, Mr. Blakesley points out that the limits of long distance telephony are reached when the upper partials are lost and the motion of the electricity becomes approximately harmonic.

The assumption that a telephone circuit degrades a tone like, say, that of a violin into a pure harmonic tone, or at least tends to do so, seems to need proof. Suppose a tone made up of two simple tones an octave apart, made, say, by two stopped organ pipes. Suppose first that each pipe has a telephone to hear it alone, and a circuit to a distance. At the distant station two receivers are provided, but the flexible tubes to the ear pieces communicate, and the hearer listens to the sounds. We can then see that the two simple tones are affected to a certain degree, and their superposition at the receiving station will give a certain tone. Suppose, now, only one telephone line and receiver to be used for both pipes. Will the hearer find no difference in the tone? Of course, no one denies that in many cases the upper partials, especially the high ones, are toned down or removed. For example, many words, such as those with many sibilants, are indistinct. The same thing occurs in acoustics. For instance, if a church is full of people, or full of clothes, which is the important point, you use more mutation stops. Whether circuits affect a periodic current in the same way as if the current was split up into harmonic currents transmitted separately and combined is a matter of some interest, and we would like Mr. Blakesley to tell us about it, as regards self-induction as well as capacity.

In discussing transmission of power by alternating currents Mr. Blakesley of course assumes the curve of sines and constant coefficient of self-induction. He assumes the motor to have a lower E.M.F. than the dynamo, which is hardly a condition available in practice, as a motor may have to run at no load for considerable times. Such a motor at no load leads. At full load it may still lead, or may be cophasedly synchronised, or may lag; but if it leads at no load it takes an armature current, and thus wastes power. We have not Dr. Hopkinson's paper by us, but think he did not discuss the question of a motor with less E.M.F. than the generator. Such a motor is really a series motor, and it will keep in step without dependence upon self-induction or field reactions. At no load it increases its lead till it gets no power. If a belt were now put on and a little power given to it, it would lead still more, and begin to act on the resistance of the circuit as a dynamo, and we would then have Mr. Blakesley's case of two alternators synchronising in series. We may mention, by the way, that the terms "lead" and "lag" should be better defined, as writers use them differently. Two machines coupled to work cophasedly synchronised in parallel, are half a period out of step if considered as series machines. If there is no external circuit, so that one is regarded as a motor, it may be said to be in step, or to lead or lag half a period. If they alter in phase another difficulty arises, just as in the case of a clock, which may be called five hours slow or seven hours fast with equal propriety.

The book goes on to give Mr. Blakesley's very ingenious methods of using several dynamometers. These methods again depend for their accuracy entirely on the assumption of the curve of sines. How far out the results would be in practice it is impossible to say. This assumption may be, and often is, useful to see, roughly, what may happen with ordinary alternating currents, but it cannot give results of any great accuracy.

Many of the calculations are wide of the mark, apparently owing to Mr. Blakesley's acquaintance with electrical engineering being very limited. For instance, an electrician does not take two alternators, and then find out at what load they will give their maximum efficiency as dynamo and motor. The dynamos are probably already at a station, and feed mains, the E.M.F. being practically independent of the motors. He then has to design a motor to work with a load varying between two limits, and the armature loss must not cause excessive heating. The discussion of two dynamos working in series and giving a total output of 154, or, rather, 153·96 watts, looks absurb, when the standard sizes of alternators are 50,000 watts and upwards.

Mr. Blakesley has a command of mathematics, which many of us may envy; but he does not seem to realise that mathematics is merely a tool, though, of course, a very useful one. A string of mathematical calculations based on assumptions which cannot be quite true, and may be very far from the truth, is not of very great practical value. A mathematician is like an amateur with a high class lathe. He may apply it to useful work, but he is more likely to devote his attention to elaborate ornamental turning, and then to wonder that the practical man does not think very much of his work. If he is a pure mathematician, he will devote his whole attention to making himself more tools.

Many purely mathematical writers—or "college men," as they are sometimes called—are a little apt to write for the practical man, and to find that he does not eagerly devour the pearls scattered before him. One reason for this is that the college man deals with what the author of Erewhon calls "hypothetics." His alternating currents are harmonic, his engines are worked by perfect gases, his ships go through water whose resistance varies as the square of the speed, and have flat sails, and so on. Theoretical writers frequently do not know what practical men want; while if they took time to find out they would not have time to become good college men. The engineer has to use his life as well as he can, and get the largest knowledge of both kinds possible in the time at his disposal. If these kinds of knowledge are balanced he is a true theoretical or practical man, the terms having properly the same meaning; but if he knows more of one and less of the other he tends to be a tinker or a college man, as the case may be. Among electricians especially mathematics is a little too apt to excite the sort of admiration an old lady gave to her favourite preacher, who was always using long and blessed words like Mesopotamia.

Mr. Blakesley's book must have taken great labour, and is very carefully written. A great many of the problems dealt with may be nearly correct, or, at any rate, the assumption of harmonic currents may give results near enough to give a very much better idea of what happens than could be readily got otherwise. Moreover, we are quite aware that though we may consider some parts of the book to contain unnecessary refinements, and other parts to be practically useless, many people will not agree with us, and they will find the work exceedingly valuable.

The A B C of Electricity. By WM. H. MEADOWCROFT. Endorsed by T. A. Edison. London: John Heywood, 1, Paternoster Buildings.

At the commencement of this work we meet with the following:—"To the English public . . . . . 'Professor' Edison's endorsement on the preceding page speaks for itself." The addition of a "handle" to a name in order to duly impress the public is no doubt a convenient device, but it will hardly produce the effect with the British public which no doubt is anticipated. We are only surprised that the author does not dub himself "Professor" also as he would immensely add to his apparent importance by so doing and would gain prestige at a cheap rate. Though we can speak well of Mr. Meadowcroft's production, in several places he is hardly careful enough to speak with scientific accuracy. At the threshold of the work the author would lead the reader to consider weight as identical with mass and he practically states that a pound pressure is the same as a pound weight. Taking his general explanations of the volt, ampère and ohm (with which explanations the book practically commences), he certainly puts the same in a manner eminently calculated to give the elementary student, or the general public, a very fair idea of what is meant. Considering the small size of the work the writer goes over a large amount of ground, the telegraph, telephone and the electric light being included in the pages. It is an extremely difficult thing to write a satisfactory elementary work, especially in a limited space, but Mr. Meadowcroft has certainly succeeded in doing what many have failed to do, and his A B C of electricity should become popular among that class of people for whom it is written.

Anticipating the Weston Armature Patent.—Mr L. Stark, writing to the *Electrical World*, says:—"It may be interesting to your readers to hear something about the oldest anticipation of Weston's famous armature patent. This is an English patent of T. L. Pulvermacher, ex anno 1849, named, "Galvanic Batteries, Electric Telegraphs, &c." On page 17 there is described an "electro-magnetic arrangement," consisting essentially of a separately-excited field magnet cylinder with inwardly projecting teeth, and an armature rotating inside this cylinder, and provided with outwardly projecting teeth. Both of the parts are formed of a series of toothed or notched rings formed of thin plates of soft iron. "Every ring is separated from, or has interposed between it and the next ring, a ring of exactly the same form, but made of brass, gutta-percha or some other non-magnetic material." I hope that this communication will form another argument contra the validity of the said patent, and I request you, therefore, to insert it in your columns."

NOTES.

Electric Lighting at Falmouth.—At a meeting of the Falmouth Town Council last week, Mr. Williams moved "That the time had arrived when this authority should apply for an Act of Parliament for powers to supply Falmouth with the electric light, and that the Parish Local Board, the Pendennis Lighting Committee, and the Corporation of Penryn be asked to join in the scheme." A short discussion ensued, and the matter was eventually referred to the Lighting Committee.

The Electric Light at Wrexham.—We hear electricity is being introduced with surprising rapidity into the collieries, works, hotels and breweries in the Wrexham district. 100 lamps of 16 and 32 candle-power, fitted up in the offices, engine rooms, stables, &c., at the Llay Hall Colliery, were lit for the first time last week. Messrs. Sillery and Co., of the same place, tried 32 lamps at Felinpuleston Flour Mills. The electric light will shortly be introduced into Messrs. Soames and Co's. Brewery, the Wynnstay Hotel, the Cambrian Foundry, &c.

The Electric Light at the Leeds Town Hall.—The Electric Lighting Committee met last week to witness experiments with the Brockie-Pell arc lamp for illuminating the exterior of the Town Hall. The results were very satisfactory, and it is intended in about a fortnight to have eight lamps fixed around the Town Hall.

Electricity in Barnsley.—The Barnsley Gas Company have raised the price of gas, which has caused a considerable amount of dissatisfaction. A meeting of consumers was to be held last Tuesday evening to consider what steps should be taken with a view to opposing the advance in the price. Already several private firms have adopted the electric light, and in the present position of affairs it is more than likely that electricity will be greatly favoured.

New South Wales and the Electric Light.—*Colonies and India* says the use of electricity for lighting purposes is rapidly spreading in this Colony. A short time ago the inland towns of Young and Tamworth were lit up with the new substitute for coal gas, and, through the enterprise of the people who introduced the new light to the Colony, quite a number of towns are now preparing to follow the example of the places mentioned. The Moss Vale folk have now resolved to make use of the electric apparatus for lighting their township, a circumstance which will probably be appreciated by the Governor as much as anyone, there being a Government House-of-ease in the immediate vicinity of the picturesque Moss Vale.

Lighting Contracts Wanted.—For lighting the public streets of Wimborne Minster for three years from October 21st, for the rural sanitary authority of Wimborne and Cranborne Union. The contractor to provide gas, oil, or other lighting matter, and to provide and keep in repair all necessary lamp posts, brackets, lanterns and all appliances required for lighting, and labour for the cleaning, lighting and extinguishing thereof. Form of tender may be obtained at the office of Mr. Frank H. Tanner, clerk, Church Street, Wimborne, on payment of £2 2s., to be returned to the parties whose tenders are not accepted. Tenders to be delivered at the office of the clerk by October 16th.

A Difficulty.—We understand the Metropolitan Electric Supply Company has met with the opposition of the local authorities in laying mains in Kemble and Sardinia Streets. While the men of the company were throwing out the earth, men commissioned by the vestry threw it back, and these amusing proceedings lasted for some considerable time. Some temporary arrangements were at last made, and the work for the present stopped.

A Palace Lighted by Electricity.—A splendid palace is being erected a few miles from Dublin for the Archbishop of Dublin. The whole building will be lighted by the electric light.

Another Exhibition.—An international exhibition of arts, science, manufactures and trades will be held at Hove, near Brighton, from the 30th September until the end of December. There will be a special section devoted to electricity. Applications for space should be made to the managing director of the exhibition, 14, Pavilion Buildings, Brighton, or at 20, Bucklersbury, London, E.C.

The "Telegraphophone."—This instrument has recently been devised by a Mr. Wheless, of Nashville, America. In this instrument the graphophone records are made to actuate a telephonic transmitter, which in turn actuates a receiver, which records on a graphophone at the receiving end of the line the words spoken into the graphophone transmitter. The general idea, it is, perhaps, needless to say, is by no means new, though no doubt Mr. Wheless's method of carrying it out possesses points of mechanical novelty. The invention has for its object the overcoming of what is stated to be a "serious" defect in the ordinary telephonic system, viz., that if a subscriber is called and there is no response, the caller must wait for another opportunity to communicate; this "serious" defect, the system of having a permanent record, is to overcome. With inventors there is always something "seriously" wrong with a system which they fancy they can improve, as in the present case. But even supposing the whole apparatus could be made to work efficiently in connection with an exchange, the abuses to which it would be liable are numerous; the temptation, for instance, to record a volley of abusive language for the delectation of the hearer, who would be expecting an important communication, would in many cases be irresistible. Again, practical experience has again and again proved that automatic apparatus of the kind can never be relied upon, however perfectly all the details may have been worked out. Even the simplest form of self-starting telegraphic apparatus has never been found in practice to be depended upon to record its signals, unless a call has been made and responded to before the message is sent.

The "Peral."—The account published by the New York *Sun* regarding the explosion and sinking of the *Peral*, submarine torpedo boat, in the Bay of Cadiz, is stated by an American contemporary to be absolutely without any foundation of fact. At the date when this catastrophe was supposed to have happened the *Peral* had not even been tried in the open bay, the experiments up to August 27th having been in the dock at the Arsenal. On August 7th the first trial at which representatives of the press were permitted to be present, the electric submarine boat proved to the satisfaction of the spectators that at all events, in the smooth water of the dock, the boat could be submerged and maintain its proper position under water. Those on board included Mr. Isaac Peral, the inventor, five officers and the crew. The cigar-shaped boat was closed, sank about three feet below the surface, and performed some evolutions at that depth, rose to the surface again, and repeated the test about six feet below the surface. The result of the trial was that the boat seemed to be under perfect control below water, and that in the short space of time of the test the respiration of those on board was normal without having recourse to the stored air or the apparatus for purifying it. The trial in the Bay of Cadiz, which took place on the 27th ult., was in a rough sea, and possibly on this account the submarine qualities of the boat do not seem to have been tested on this occasion; but the manœuvres of the boat on the surface seem to have been quite successful, discharging torpedoes, &c., and elicited the highest approbation from the Italian squadron, which happened to witness the performance.

Magnetic Wells.—We reproduce the following, now going the round of the press, as being too good to lose sight of. We hear the magnetic wells of Michigan are now being inspected by Prof. Jarentski, of Paris, in the interest of a syndicate of Frenchmen, who propose to utilise them for industrial purposes. The theory is that at some depth there will be found a stratum of mineral heavily charged with magnetic electricity, which may be brought to the surface and utilised to run mills and factories independent of other force. The wells are now flowing water from the depth of 800 feet so highly charged with electricity that a knife-blade or steel bar held in the water for a few minutes becomes highly magnetised. While the drillers were at work upon the well, they found that their tools became magnetised, and that a steel line used in measuring the depth became highly charged.

The Jarman Electric Car.—On Wednesday night a run of Jarman's electric car was made from the works of the Electric Tramcar Syndicate, Plough Yard, Clapham, to Blackfriars Bridge. A start was made at half past twelve, and Blackfriars Bridge reached at one minute to one, or nearly 4 miles in 29 minutes. The return journey was made in 37 minutes, including stoppages. There were present the manager and secretary of one of our suburban tramways, and several other gentlemen interested in tramway enterprise. This is the twenty-eighth journey made by the car.

Electric Lighting in London.—The *Financial News* says the repaving of the Strand has been the means of bringing to notice the fact that electric lighting is becoming a serious actuality in London. Then, after detailing what is being done by the various electric light companies, concludes :—Meanwhile, the public authorities allow the streets to remain dimly lighted with gas. How long is it to be so?

An Imaginary Nuisance.—At the Brighton County Court last Friday, before Judge Martineau, Messrs. W. G. Bate and W. Robinson applied for an injunction to prevent Messrs. H. R. de Salio and T. Bambridge from using a gas engine, and to recover damages for an alleged nuisance. It appears that plaintiffs are the occupier and owner respectively of No. 43, Church Street, Brighton, and the defendants keep a gas engine for the purpose of driving a dynamo in a shed at the back of No. 44. Mr. de Salio used the dynamo for producing the electric light and for experimental purposes. It was alleged that the vibrations from the engine were so great that it prevented the occupants of No. 43 from sleeping whilst the engine was running, and that reading and writing were rendered difficult. The Judge said he had visited the premises when the engine was in full work, and he found that there was practically no cause for complaint. The whole case was a gross exaggeration. He therefore gave a verdict for the defendants with full costs.

Improved Clark's Standard Cell.—A modification of this standard cell has recently been devised by Professor H. S. Carhart, of America. One important feature in this cell, a feature which we think is well worth notice, is the addition of a high resistance included in the case of the cell, so that the latter cannot possibly be short circuited.

Lectures on Elementary Physiology and Therapeutics.—A course of ten lectures on the above subjects is about to be given at the Institute of Medical Electricity, Limited, by Mr. Arthur Harries, M.D., and H. Newman Lawrence, A.I.E.E.

Repaving of the Strand.—We extract the following from a letter sent to the *Globe* by the vestry clerk :—"The traffic of this important thoroughfare having resumed its wonted aspect, and a great deal having been written and said during the execution of this work reflecting upon the vestry, its officials, and others concerned, I shall be glad if you will afford me the opportunity of stating a few facts in relation thereto. Taking up the old wood paving began on the 12th ult., a period of the year most suitable for carrying out such work, as being least liable to interfere with business and the interests of the ratepayers. On the following day notice was received from the Metropolitan Electric Supply Company of their intention to lay a main with transverse branches about every 50 feet apart under the portion maintained by this vestry, and the vestry having waived many formalities in order to expedite the carrying out of the work, the company proceeded with all expedition. This of course necessitated the suspension of the repaving for some days to allow the company to get ahead. Simultaneously Messrs. Gatti, by permission of the vestry, were laying a main between Villiers Street and the Adelphi Theatre, and subsequently between the Adelphi Theatre and Exeter Street. The work performed in laying these mains was first to cut through a layer of asphalte 1 inch thick; then concrete from 6 inches to 12 inches thick, excavating to a depth, in some cases, of 7 feet, and having to contend with difficulties which only those who are acquainted with such matters can appreciate, namely, 25 pipes, varying from 24 inches to 6 inches in diameter, with services and branches which exist in this thoroughfare from front to front. During this portion of the work about 200 men were employed. Beyond the work of the electric companies, the gas and water companies made numerous openings. It will be apparent to any experienced person that, with two electric mains being laid, and under the circumstances alluded to, the censure and complaints that have been prominent in many of the papers were made without a knowledge of the facts of the case. Making good these trenches, amounting in length to 3,724 feet, or about 1,010 superficial yards, caused further delay owing to the new concrete having to remain some time before being paved over. As a part of the difficulty the dock strike seriously affected us, the contractor for wood blocks (Mr. J. Knights) having been put to great difficulty in supplying us. Notwithstanding these difficulties the works have been completed within five weeks.

Accident to an Electric Car.—A Central News telegram from New York says :—An electric railway car was proceeding up Mission Ridge yesterday, conveying about 50 sightseers to view the battlefield, when, for some unexpected reason, the conductor lost all control over it, and the car dashed down the mountain-side at terrific speed. One man was killed, and 16 others were more or less severely injured in jumping from the carriage.

Personal.—A meeting of a pleasant and interesting nature was held at the Edison and Swan Company's Works, Ponder's End, on the evening of Thursday, 19th inst. Mr. Edward Gimingham (the resident superintendent's brother) has recently undertaken a responsible position in the factory, and just attained his majority, and the officials considered it a fitting opportunity to make him a present as a slight token of their respect and esteem. Mr. Robson (foreman of the works) was asked to preside. He explained the purpose for which they were met, and in handing the present—a Wortley writing desk with a suitable inscription—to Mr. Gimingham on behalf of the officials referred briefly to their long connection with him, and the high appreciation in which he was held by them.

Mr. E. L. Joseph has resigned his position with Mr. Julius Sax, and has joined the firm of Messrs. Appleton, Burbey and Williamson as traveller.

Organ Blowing by Electricity.—Real practical success at length has been attained by the "C and C Electric Motor Company," of New York, which has now placed its motors in St. Paul's Church, St. Patrick's Cathedral, the Collegiate Reformed Church, and the Madison Square Church. Contracts have been signed for several other churches. The advantages of the motor over other means of blowing the bellows are so evident that it is only a question of time before all churches within reach of electric current will be provided with this appliance. Henceforth, the organist is independent of the pleasure of the blower, or the vagaries of the gas engine; he merely touches a button, when the organ, obedient to his touch, gives forth its tones. During the last four months motors of upwards of 100 horse-power, in sizes ranging from 1 to 20 horse-power, have been placed in New York City alone.

Lectures on Dynamos.—The recently-issued winter programme of the City and Guilds Technical College, Finsbury, shows that electricity is still a leading feature, as it has been for so many years, in the College course. In addition to the usual courses of lecture and laboratory work, elementary and advanced, there is a course of instruction in the electroplating laboratory under Mr. E. Rousseau, and a series of special lectures on the design and construction of dynamo machines, by Professor Silvanus P. Thompson. This course, which begins on Monday, October 7th, deals with armature designing, commutators and brushes, field-magnet designing, calculations of windings, and details of construction; also with alternate-current dynamos, motors, arc-lighting machines, and transformers. For terms see our advertisement columns.

As will be seen in an advertisement appearing elsewhere, Mr. Esson also is about to deliver a course of lectures on the dynamo. The study of this machine is most interesting, and will doubtless be of great benefit to those who attend the course.

Aspinall's Enamels.—We have recently made a trial of these well-known enamels with reference to their insulating properties, and the results of our experiments prove that a coating of the material on metal has an exceedingly high specific resistance; the enamels should therefore prove of considerable value for electrical purposes.

Frank J. Sprague.—This prominent American electrician is the subject of a short biographical sketch in the *Electrical World* for September 7th. Mr. Sprague, after serving a few years in the Navy, was promoted, and availed himself of opportunities for electrical work at the Stevens Institute, Hoboken, and at the Newport torpedo station. Having put his ideas and inventions into practical shape, Mr. Sprague went to the Philadelphia Exhibition with several motors bearing his name. The work created a most favourable impression, and the result was the formation of the Sprague Electric Railway. Since then the work of the motor has spread to an enormous extent, and in America Sprague motors are to be found in almost every city.

Extending Ladders.—Electrical progression is demanding portable extension ladders of a kind not hitherto thought of, and the British Museum has just purchased from J. H. Heathman and Co., of 11, High Street, Bloomsbury, one of their extension ladders, which telescopes from 20 feet up to 36 feet 6 inches, or any intermediate height, as well as a novel platform upon wheels, which passes through a door 4 feet wide by 11 feet high, and occupies a base 6 feet long. By means of a twin rope a step ladder rises to 18 feet high, and the whole can be moved about freely by one man.

Mr. Edison in London.—Mr. Edison, who is at present the guest of Sir John Pender, at Foots Cray, visited London a few mornings ago and inspected the various electric lighting stations of the Metropolitan Electric Supply Company, Limited, five of which, having a total capacity of 150,000 lamps, are either completed or in progress in various parts of London. Mr. Edison was accompanied by Sir John Pender, Sir George Elliot, and Mr. J. E. H. Gordon, the engineer of the company, by whom the various details of the machinery were explained. Subsequently Mr. Edison and Sir John Pender visited the Reform Club. In the afternoon, Mr. Edison and Mrs. Edison paid a visit of courtesy to the Lord Mayor and the Lady Mayoress, at the Mansion House, and were entertained at luncheon. They were accompanied by Miss Miller (Mrs. Edison's sister), Sir John Pender, Sir James Anderson, Mr. Tait, Colonel and Mrs. Gouraud, Mr. Leyland, and Mr. J. S. Forbes; and among those asked to meet them at a very short notice were Lord Rothschild, the Governor of the Bank, Lord Brassey, Sir John Lubbock, the sheriffs, and several of the aldermen. There were no speeches. Mr. Edison's stay in this country is too short to enable him to accept the Lord Mayor's invitation to a banquet which he proposed to give in his honour.

Motive Power.—"When there is such a power as electricity adaptable to tramway traction it seems like a weak compromise to change from horse-power to any other system. Yet in France the use of compressed air is extending, the tramways of Lyons being on the point of adopting it. The cost is much less than that of coal, and the speed attainable is very good."—*Financial News.*

Mr. Edison on Mr. Preece's Views.—We hear that Mr. Edison in a recent interview said:—How would Mr. Preece explain the deaths of 28 people killed in the electric power depôts of the United States by the alternating current in a year, and the instantaneous death of the cattle subjected to our experiments? Mr. Preece pretends to have submitted without injury to an electric shock of immense force. He is really ignorant of the value of the term "immense" in electricity. Everything depends on the method of operating. Steep your hands in soda water before touching an electric wire, and you will not even experience a shock. Whatever may be said at Newcastle, the criminals condemned to death in the State of New York are going to be executed, and will never again be executed, by any other agent than the electric fluid, the most expeditious and humane of all methods.

Salford Corporation and Electricity.—At a meeting last Friday the Corporation decided to apply for the necessary powers to enable them to supply electric light for private purposes. This step was not taken voluntarily, but in self-defence, a private company having given notice of its intention of applying for a provisional order.

Sudden Death of an Electrician.—Mr. Charles Heaton Sharples, F.C.S., died suddenly at his residence, Preston, on Sunday afternoon. Mr. Sharples was the junior member of the firm of Sharples and Son, chemists and electrical engineers, Fishergate, Preston. During his lifetime Mr. Sharples held a prominent position amongst the scientists of the town. He was a Fellow of the Chemical Society and a member of the Institution of Telegraph Engineers. He was the first to introduce the telephone into Preston by the establishment of the Preston Telephonic Exchange Company, which, after a few years' existence, was taken over by the Lancashire and Yorkshire Telephone Company.

Tenders for Telegraph Stores Wanted.—For the supply of 8,041 red fir telegraph poles, to be delivered in London or at Sutton Bridge, and 7,047 to be delivered at Northumberland Dock (River Tyne), West Hartlepool, Hull, or Grimsby, for the Postmaster-General. The poles to be felled between November 1st and February 28th, 1890, and to be delivered during the following summer. Also for creosoting the above poles with either 8 lb. or 10 lb. of creosote to the cubic foot, as may be decided. Forms of tender, containing all particulars, may be obtained on application, either personally or by letter, to Mr. C. E. Stuart, Controller of stores, Telegraph Street, E.C., Tenders will be received until noon on October 21st.

The Electric Motor in South Africa.—Messrs. Hornsby and Sons, of Grantham, are making machinery for African gold mines to be worked by electric motors.

Woodhouse and Rawson's Wiring Tables.—In our issue of July 19th last we made some comments on new wiring tables about to be published by Messrs. Woodhouse and Rawson. The remarks we then made have borne fruit in the production of a revised chart containing two tables. No. I. having been re-arranged and calculated with the allowance for temperature, may now be taken as a safe guide for ordinary practical work. It gives the number of yards to which currents from 0·5 to 420 ampères can be carried, with a loss of 2 volts, by a copper conductor of 98 per cent. conductivity; it also indicates by figures of heavier type the (approximately) largest currents which can be carried by the respective cables in each row with a limit of current density of 1,000 ampères per square inch, and at this density, with perhaps the exception of the 61/13 cable, all the cables are well within the range of increase of temperature allowed by such an insurance office as the Guardian. It would be handy if another column were added for the areas of the several conducting strands, if only for comparison, as all makers do not manufacture their wires to the same gauge. We understand that Sabine's law of heating has been taken as the basis of the calculations, and that although the results are not actually definite they are near enough to the truth for all purposes Messrs. Woodhouse and Rawson had in view. They appear to have a reasonable margin of safety in the carrying capacity of the cables—for instance, take a 37/12 conductor, and it will be found that the table fixes a limiting current of 300 ampères, while on referring to a table issued by the insurance offices, 340 ampères is given for the safe carrying capacity of the same 37/12 cable; by safe capacity is meant such a carrying capacity in the conductors that they shall not be raised in temperature more than about 10° centigrade, or 18° Fahrenheit. As Sabine's law has been followed, it should be printed with the other data at the head of the tables. Table II. shows the distance to which any current is conducted by a cable with a given current-density and a given fall of potential. This table having no temperature corrections, must be used with care; but it has been greatly improved since it first came under our notice by the omission of all currents exceeding 2,000 ampères per square inch of conductor, so that as it stands the error is not likely, at the worst, to exceed a comparatively small percentage, and this can be allowed for by the estimator. It will no doubt be found that the ease with which this table can be used will counteract, in the estimation of most persons employing it, this want of accuracy. The table gives approximate results for losses of potential varying from ·5 to 5 volts. Some particulars are shown in relation to its use with alternating currents. By means of four rules many other particulars can be seen, almost at a glance, relating to the given conductors, and as the whole information is contained on one sheet electric engineers and contractors will find the tables of much service as a ready reckoner.

Strike at the Silvertown Telegraph Works.—About two-thirds of the men employed at the above works are out on strike, the remainder continuing work. The company declare they cannot make any further advance, as the competition with Glasgow is too keen, at which place wages are 10 per cent. less and the cost of coal and fuel is 30 per cent. less.

Henley's Telegraph Works.—We hear that the old works of the late W. T. Henley, North Woolwich, which have been standing unused so long, are shortly to be occupied by an electrical manufacturing firm.

NEW COMPANIES REGISTERED.

John Wild and Company, Limited, (Falcon Iron Works, Oldham).—Capital, £10,000 in £5 shares. Objects: To carry on business as mechanical and electrical engineers in all branches. Signatories (with 1 share each): J. H. Fisher, John Wild, C. Clegg, James Prockter, R. Scott Collinge, all of Oldham and neighbourhood; James Wild, Failsworth, near Manchester. Registered 23rd inst. by Hooper and Son, of 69, Ludgate Hill. Registered office, Falcon Street, Oldham, Lancaster.

Hamilton Griffin and Company, Limited.—Capital, £20,000 in £1 shares. Objects: To transact business as general and financial agents. To acquire concessions, or other authorities for the construction, maintenance, management, and working of railways, tramways, telephones, electric light and power systems, and waterworks, in any part of the world. Signatories (with 1 share each): Hamilton Griffin, M.D., 16, Frognal, N.W.; B. G. Godfrey, M.R.C.S., Balham; C. Breach, Kingston Hill; Holland Dell, 4, Great Winchester Street; J. B. Hendry, 376, Strand; W. L. Cooper, 7, John Street, Adelphi; E. C. Stewart, 84, King George Street, Greenwich. Most of the regulations of Table A of the Companies Act, 1862, apply to the company. Registered 24th inst. by W. L. Cooper, 29, Essex Street, Strand.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Consolidated Telephone Construction and Maintenance Company, Limited.—The annual return of this company made up to June 13th was filed on the 23rd inst. The nominal capital is £307,545 divided into 75,000 6 per cent. preference shares of £1 each (15,000 issued, but not allotted until June 20th, 1889), and 24,850 ordinary shares of 14s. each (all issued), 150 ordinary of £1 (unissued), and 75,000 ordinary shares of £1 (unissued). Upon the shares issued the full amount has been called and paid.

British Electric Propulsion and Traction Company, Limited.—The annual return of this company made up to the 20th inst. was filed on the same day. The nominal capital is £5,000 in £1 shares. 3,191 shares have been taken up, 3,184 being considered as paid up, upon the remaining shares £7 has been paid. Registered office, 50, Gresham Street.

Chelsea Electricity Supply Company, Limited.—An agreement of 10th inst. provides for the issue of fully paid shares in payment for money advanced and services rendered. The agreement was filed on the 18th inst.

Nightingale Automatic Electrical Machine Company, Limited.—The registered office of this company is now situate at 28, Hatton Garden, E.C.

Williamson Electrical and Engineering Company, Limited.—The registered office of this company is at 14, St. Ann's Square, Manchester.

CITY NOTES.

The Direct Spanish Telegraph Company, Limited.

In the report and accounts of the directors for the half-year ended 30th June, 1889, to be presented at the general meeting of shareholders, to be held on Tuesday, 1st October, 1889, the annexed accounts for the half-year ended 30th June, 1889, show, after providing for debenture interest, a balance to the credit of profit and loss of £5,300 0s. 7d.

The traffic receipts are in excess of those for any half-year since the formation of the company, and show an increase of £508 6s. 10d. as compared with the corresponding half-year of 1888.

The working expenses are £4 16s. 4d. less than in the corresponding period of last year.

With the exception of the interruption of the Bilbao cable from the 11th to the 27th January, referred to in the last report of the directors, the company's cables and the land lines in connection with them have continued in good working order.

The cost of the repairs of the Bilbao cable have, as intimated in the same report, been paid, partly out of the reserve fund, and partly out of revenue, in the following proportions:—£1,500 from the reserve fund, and the balance (£1,442 9s. 2d.) out of revenue.

The directors have put £2,500 of the balance of profit and loss to the reserve fund, which now amounts to £14,837 19s. 10d., and there remains an available balance of £2,800 0s. 7d. Out of this amount the directors recommend the payment of the dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend at the rate of 5 per cent. per annum (free of income tax) on the ordinary shares, carrying forward £44 8s. 7d. to next account.

The dividend warrants will be issued on 1st October.

The Eastern Extension, Australasia, and China Telegraph Company, Limited.—This company notifies that their accounts for the half-year ended June 30th last show, subject to audit, a balance of profit of £107,486, after payment of the interim dividend for the first quarter of the year. The directors have declared a dividend for the quarter ended June 30th of 2s. 6d. per share, payable, free of income tax, on the 15th prox., and have decided to charge £50,000 against revenue on account of the Western Australian cable, carrying the balance of £26,236 to the next account.

Reuter's Telegram Company.—At a board meeting of Reuter's Telegram Company held on Wednesday, the directors declared an interim dividend at the rate of 5 per cent. per annum, free of income tax, for the half-year ending the 30th of June last, payable on the 12th prox.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The traffic receipts for the weeks ending 13th September and 20th September, 1889, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were respectively £1,128 and £2,071.

AMERICAN NOTES.

By DAS TELEPHON.

In matters historical anent telegraphy the records of Baltimore show that the first electro-magnetic recording telegraph line was established by Prof. Morse between Baltimore and Washington; and that the *Sun* was the first newspaper in the world to make use of the electric telegraph in May, 1844—the first Presidential message ever transmitted by telegraph was exclusively sent to the *Sun*.

The Western Union Telegraph Company raised its tariff on 1st September between New York, Boston and Philadelphia to 20 cents for 10 words, and 1 cent for each extra word, under an agreement with the Postal Telegraph Company, which is the only formidable opposition to the great telegraph *water* monopoly.

The Western Union Telegraph Company opposes the laying of its wires in the underground conduits under the streets of New York, and has brought suit in the U.S. Circuit Court to prevent the Mayor of New York from enforcing the order that the lines shall be put into the conduits.

In the bill filed the Western Union Company allege, under oath, that the proximity of steam, gas, and sewer pipes to the conduits destroyed the wires in them; that it is impracticable to keep the wires in the subways. In fact the conduit system in New York is an established failure, as many of the single wires and cables of 100 wires have already been destroyed by the steam, gas, and sewer escapes.

Mr. Baldwin, who has been connected with the company for 15 years, has had charge since February 1st, 1884, of all the aerial and subterranean wires, cables, &c., of the Western Union in this city and vicinity. Under oath he describes the company's experiments with an underground system on its own account. He likewise details his experience with the city's subways, and points out their impracticability.

The first of the latter subways used by the Western Union was that between its main office, at No. 195, Broadway, and Exchange Place, on Broadway, in November, 1887. Mr. Baldwin makes oath:—

"We put two cables of 60 conductors each in that subway. In February, 1888, they began to fail. They were examined and found to be injured in the different manholes of the subway, the injury being caused, as we determined, by the workmen of the subway company, who performed their duties in the boxes carelessly. In April, 1888, about 20 of the conductors in the cables failed near Exchange Place, and we found that the insulation had been destroyed by the heat from the steam pipe in the ground near the subway. We repaired them in May, 1888, we closed our office at No. 63, Broadway, to which these cables were connected, and we then extended the cables, one to the Produce Exchange and one to the Consolidated Exchange, through subways under Broadway which had been built by the Subway Company about that time. Since then we have added one cable in this subway to the Produce Exchange and another to our office at No. 16, Broad Street, to connect with the Stock Exchange, ocean cables and other wires, by way of subways constructed through Exchange Place and Broad Street. During every month since that time conductors in each of these four cables have failed, and in the majority of cases these failures have been caused by steam heat from the steam pipes underground between our main office and Exchange Place. On two occasions the heat was so intense that it was impossible for our workmen to enter the boxes to repair the wires and cables, though the manhole covers had been left off for several hours.

"In December, 1887, in compliance with a notice from the Board of Electrical Control, we placed two cables, containing 60 conductors each, into the subway conduits from our main office, up Broadway to the corner of Vesey Street, then across Broadway, through Park Row, to the City Hall Station. In February, 1888, the wires in these cables began to fail, and continued to do so until August, 1888. On the 14th of that month, two-thirds of the wires in one cable having failed, the part of the cable in that subway between Beekman and Fulton Streets was pulled out and a new section substituted for it. The insulation of the cable taken out was found to be entirely destroyed, the insulating material having been baked out by the heat, and being in such a condition that it fell apart upon the slightest tension.

"On October 14th, 1888, two-thirds of the conductors in the other original cable had failed, and the section of it between Beekman and Fulton Streets was pulled out and a new cable substituted. The defective section was so badly baked and rotten that it broke in the pipes when we were engaged in taking it out, and we had to remove it in pieces.

"During the next month, November, 1888, and up to the 13th day of that month, the conductors in each of these new cables had failed so rapidly, by reason of the heat coming from the steam pipes near the subway, that we were compelled to call the attention of the Consolidated Company, which had constructed the subways to it; and thereupon the Board of Electrical Control gave the Western Union Telegraph Company permission to substitute aerial wires on Park Row. The two new cables that were taken out were found to be in precisely the same condition as those previously removed, the insulating material having been so completely destroyed as to allow the wires to connect with each other or with the ground, thus making them entirely useless for telegraphic purposes."

The experience of the subways of New York may be of service in London and other large cities.

The Commercial Cable Company has filed a certificate, as required by law, of an increase of capital from six to ten millions of dollars, for the purpose of retaining six million of debenture bonds.

An electrical letter-stamping machine is now on trial at the Post Office Department, which cancels 24,000 stamps an hour. The Postmaster-General is much pleased with the work it turns out. The best a man can do with the hand stamp is about 3,000 letters an hour. The machine works all the details automatically, and stamps clearly and accurately.

The Vanderbilts are having a large number of motors built to be used on their street railways. There are now 109 street railroads using electric motors in the United States.

A company in Connecticut, the land of wooden nutmegs, has organised a company to manufacture self-winding clocks, the motive power to be electricity, generated by two Leclanche cells, which do the work effectually for 12 months without renewal. The clock is wound every hour by a current from the battery operating on a pair of magnets. The main wheel, which makes a revolution once an hour, closes the circuit at every revolution. When the circuit is closed momentarily, the armature is pulled towards the magnets, drawing with it a lever, which moves one tooth of the ratchet wheel fastened to the case containing a fine steel spring attached to the centre pinion. This operation is repeated for five seconds, at the rate of three blows a second, until the spring is entirely wound up, and then the current is cut off by the action of the main wheel.

Philadelphia is contesting with New York for the greatest subway explosion caused by sewer gas.

A Sewer Blown Up in Philadelphia.—Philadelphia, September 4th. For several weeks illuminating gas had been gathering in the sewers and drains along Vienna Street, between Memphis Street and Frankford Road. Yesterday afternoon workmen uncovered the gas main at Sepviva and Vienna Streets, and Joseph

Rink, the foreman, stepped down into the trench. Seeing that he was about to ignite a piece of paper to test the main, James Martin forced the children gathered through curiosity around the trench back and away from the opening.

Rink lit a match and applied the burning paper to the pipe. In an instant there was a terrific explosion, and great sheets of flame shot up from the culverts and manholes along the street. Foreman Rink was blown out of the trench into the streets and the workmen and the children were thrown to the ground and covered with flying mud and debris, but fortunately were not seriously injured. Pieces of the iron work around the opening of the culvert were blown 50 feet into the air. The sewer from Tulip to Sepviva Street was torn up, and paving stones and dirt were thrown in all directions. On Vienna Street there is a large hole where the sewer was blown completely open.

The iron cover of a manhole, weighing several hundred pounds, was blown across the street and struck the walls of the church, being broken into many pieces.

Baltimore, *September 6th*, 1889.

ELECTRIC LIGHTING IN THE CITY.

At the last meeting of the City Commissioners of Sewers, before the holidays, Mr. F. F. Day (Chairman of the Street Committee) submitted a report relative to the tenders for electric lighting, and recommending that the proposals of the Metropolitan Electric Supply Corporation for district No. 1 (West), of the Anglo-American Brush Company for district No. 2 (Central), and of the London Electric Supply Corporation for district No. 3 (East), be provisionally accepted, subject to the companies agreeing to enter into contracts for 21 years, determinable by either party at the end of 7 or 14 years; and the last named company waiving the condition as to extinguishing half the lamps at midnight.

To a motion that the report be agreed to there was an amendment that the report be printed and circulated amongst the commissioners. The amendment was lost, and the debate was ultimately adjourned.

On Tuesday last the first meeting of the commissioners after the holidays was held (Mr. George Manners in the chair), and the debate resumed. Mr. Preece was in attendance in case his advice was required, he having been the adviser of the commissioners throughout on the subject of the electric lighting of the City.

Mr. Rose-Innes stated that on the previous occasion he moved the adjournment of the debate because he thought it would be better for the streets committee to take the report back.

The Chairman was of opinion that the speaker was a little out of order. The Court had decided that the report should not be printed, and it could not be sent back. They must now go on with the merits of the case.

Mr. Innes: My motion is to refer it back to the Streets Committee for further consideration.

Mr. Deputy Bedford: We have had enough consideration of this already. We shall be the laughing-stock of the whole of the metropolis, as we shall soon be the only part of the metropolis left in darkness.

Mr. King desired permission to move another amendment—viz., that the electric lighting report of the Streets Committee be printed and circulated amongst the members.

The Chairman ruled that that could not be done, after the decision arrived at at the last meeting.

Mr. King thought that after the lapse of a month or six weeks it was time that the members knew the contents of the report.

A Member said the report had not been printed and circulated yet, and the Court ought not therefore to be called upon in a hurried fashion to vote on a question so important to the City as its lighting. He should like therefore to support the proposal that the report be printed and circulated among the members.

The Chairman stated that he had consulted a high authority on the subject as regarded the printing of the report, and it could not be done.

Mr. Sly wished to point out that the report was a most important one, and he considered that the members ought to have a proper opportunity of understanding it, which they could not do without seeing and reading it carefully. Under the circumstances, the only way out of the difficulty was to move the adjournment of the debate so as to give facilities for rescinding the resolution, which at present stood in the way of printing the report.

A Member wished to know if it was competent for anyone, in some way or another, to prevent the deadlock at which they appeared to have arrived? The report must be printed, and the members have a copy, or otherwise the matter could not be properly debated.

Mr. Pannell believed it would be for the general convenience of all to have the matter pressed forward. Therefore he desired the assistance of the officials to tell him whether he could not, in some form or other, get the report printed and into the hands of members very soon.

The Chairman: I have taken the best authority on the subject. I have asked the Town Clerk, and his ruling on the last occasion was that we could not put the motion for the printing of the report. Nothing connected with electric lighting can now be taken.

A Member: I ask to be allowed to propose a resolution.

The Chairman: If it is connected with electric lighting I shall rule that it is out of order.

Mr. Pannell: Would it not be competent for the Court to ask Mr. Preece and the engineer to say something about this report?

The Chairman: Not now. We can take nothing connected with electric lighting. That is my ruling.

Mr. Pannell: On a point of order. Is it not competent for any member to ask the leave of the Court to move any subject without notice?

The Chairman: I say no. I ruled so last time. Nothing connected with electric lighting can now be taken. The debate is adjourned.

Mr. King: Am I to understand that the adjournment of the debate has caused a deadlock?

The Chairman: It means that there is an adjournment until the next time we meet.

Mr. King: May I ask a question?

The Chairman: I really think not on this subject, as the debate is adjourned.

Mr. King: But I only wish to ask if any member, if he has the permission of the Court, can bring forward a motion without notice?

The Chairman: Certainly not if it applies to the question which we have decided to adjourn. I have decided that on the very best advice.

A Member: Does our solicitor support you? (Cries of "Order! order.")

Mr. Bridgman: If a motion can be, by the permission of the Court, brought forward without notice, it can be done now.

The Chairman: No; I have ruled differently.

After several fruitless attempts on the part of different members to continue the discussion, the debate was adjourned, and the Court proceeded to its other business.

ELECTRIC LIGHTING IN PADDINGTON.

Special Meeting of the Vestry.

On Tuesday last Mr. Jackson presided over a special meeting of the Paddington Vestry at the Vestry Hall, Harrow Road, to consider the report of the electric lighting committee as to the action to be taken by the vestry in the matter of supplying electricity for lighting purposes in the parish. The Electrical Review last week contained the more important portions of the report. The agenda paper contained notices of a number of motions in the name of Mr. M. H. Judge, who proposed that the electric lighting committee should prepare a draft order providing as follows:—

"(A) Two complete systems for public lighting, extending throughout the borough, so that the two systems may be used separately or concurrently from time to time.

"(B) Both of the public lighting systems to be completed by December 31st, 1894, except in so far as the vestry may by resolution decide that any part of the borough shall not be publicly lighted by electricity.

"(C) The number of lamps to be provided for public lighting to be subject to the approval of the vestry.

"(D) The maximum charge to be made to the vestry for public lighting, including rent of meter.

"(E) A system of private lighting, by means of incandescent lamps, to be completed by December 31st, 1894, throughout every part of the borough in which a majority of any 200 adjacent ratepayers shall make application for the light, and each enter into an agreement to fit up and maintain, for at least two years, incandescent lamps to equal a minimum of 40 candle-power.

"(F) The maximum charge to be made for private lighting, including rent of meter.

"(G) Sites for stations and works to be subject to the approval of the vestry.

"(H) That no overhead wires be used, and that all conductors be carried under the public roads or footways, with the exception that, with the approval of the vestry, the conductors may be laid underground through private property."

Mr. Judge also proposed that the conduits for conductors should be large enough for use for fire alarms or other signals; that all stations for the production and supply of electricity be within the Borough of Paddington; and that there be an audit by the vestry of the accounts of the undertakers.

The vestry, however, first proceeded to the discussion of the following resolution, which was proposed by Mr. J. J. Minchin:—"That in the interest of the ratepayers the vestry do keep the supply of electric lighting for Paddington in its own hands, and in order that such work may be carried out a capital of not exceeding £50,000 be raised on the security of the lighting rate."

Mr. Minchin said it was a momentous question that they were about to decide, and therefore they should not come to any decision before they had given full and impartial consideration to the subject. At least one year's delay had taken place in the introduction of electric lighting into the parish on account of their opposing before the Board of Trade the provisional orders that were applied for by the leading companies. And those orders were refused because the vestry told the Board of Trade that they were engaged in considering whether they should themselves supply the light. It was still possible, therefore, for them to obtain a provisional order to enable them to carry out the work themselves. The vestry had taken into council two experts who supplied them valuable information, but he confessed that Prof. Forbes's report did not appear to be nearly so practicable as that supplied by Mr. Mackie. The estimates supplied by the latter gentlemen were fairly reliable. Being desirous that the vestry should carry out the work themselves he (the speaker) had consulted with Mr. Mackie, and had laid before him a scheme of his own, which he considered was one that the vestry might fairly adopt without making any undue calls upon the hardly-pressed ratepayers. The leading features of the scheme, which he submitted to Mr. Mackie, were that arc lighting should be provided to a certain extent for the business streets of the parish in North and South Paddington, and that the private lighting for the inhabitants should be supplied throughout the whole of the parish wherever there was a sufficiently wealthy population to make a demand for it. Mr. Mackie considered that such a scheme could be fairly carried out with a capital of £50,000. Detailed estimates had not yet been prepared, but if the vestry determined that the work should be done, Mr. Mackie guaranteed that within three weeks detailed estimates should be supplied in a manner required to meet the whole of the demands of the Board of Trade in their provisional orders. Time would be gained by their carrying out the work themselves, as he believed they would be able to get a provisional order at the commencement of November. He trusted that whatever was done, the matter would not be again referred back to a committee, as they had all the necessary information to enable them to come to a wise decision. Mr. Mackie considered the £50,000 which he (Mr. Minchin) proposed to raise would suffice to supply 100 arc lamps and 10,000 incandescent lamps, and it was an accepted fact that that would meet the actual requirements of 15,000 consumers. If they had energy at their central stations to supply nominally 10,000 incandescent lamps, they had in fact sufficient to supply 15,000, because every consumer would not use all the energy allowed him. Public lighting by arc lamps was the least costly. Mr. Spagnoletti, the chief electrician of the Great Western Railway Company, was decidedly of opinion that the only economical system of public lighting was by arc lamps. As to the advantage to the vestry in doing the lighting themselves, he might state that there was not one single expert that he had consulted upon the question who did not say that it would be folly to hand over the work to any other parties, and that it was their bounden duty in the interests of the ratepayers to carry it out themselves. He believed that 100 arc lamps would be sufficient to light 7 miles of streets, and he would suggest that the two principal thoroughfares, Harrow Road and Westbourne Grove, be first lighted. The yearly cost of the installation, including depreciation and interest on capital, would be about £17,000, *i.e.*, if the whole of the light was used. But it might be that there would be a demand for only 5,000 incandescent lamps, and in that case the outlay per year would be only one-half. Ten thousand incandescent lamps at 6d. per Board of Trade unit would bring in a revenue of £29,000, leaving a profit of £12,000, and they would get the 100 arc lamps without any charge at all. The mode in which the revenue of £25,000 was arrived at was a technical matter, but it was calculated upon the Board of Trade unit, which was the basis upon which all the companies were to make their charges. Any increase of plant that might be required could be paid for out of the profits. If the electric lighting of the parish were handed over to a company, the consumers would have to pay 8d. per Board of Trade unit as against the 6d. at which the vestry would be able to supply it. Public lighting by electricity would be almost impossible through the prohibitive rates which companies did and must charge. In his opinion, if they handed the work over to any private company, they would never have any public lighting, as the charges would be so prohibitive. If the vestry only took the matter in hand, he felt convinced that many years would not have elapsed before the whole of the streets of Paddington could be lighted by arc lamps out of the profits made in supplying electric energy to private consumers. The question of what it would cost the parish was a very important one, but a halfpenny added to the lighting rate would be sufficient to give them the scheme he proposed. He earnestly hoped, therefore, the vestry would adopt his proposal, as by so doing, they would give to the ratepayers, within a very limited number of years, the boon of having the whole of the streets lighted with electricity.

Mr. Kenyon: Would this estimate of yours supply the whole of the parish?

Mr. Minchin said it would supply the whole of the demand that was expected for Paddington.

Mr. Owen seconded the motion, and remarked that he agreed entirely with everything Mr. Minchin had said. They should take that opportunity of conferring a great benefit upon the parish, and he really did not see how they could come to any other conclusion than to do the work themselves.

Mr. Mark H. Judge moved the following amendment: "That inasmuch as the electric lighting committee has not seen its way to recommend the vestry itself to undertake to provide electricity for lighting and other purposes in the borough, it is desirable that steps be now taken to secure it being done, at an early date, by private enterprise, under a provisional order approved by the vestry as the local authority, such provisional order to embody the terms upon which the local authority, if it desires, shall be entitled to purchase the undertaking at the expiration of 21 years and 31 years respectively." At some length Mr. Judge commented upon the report, and said that the references to "the model order" in the second paragraph showed how imperfectly the gentlemen who approved of the report understood the questions that were referred to them. The fact was, there were no two model orders alike. A model order was simply a basis upon which to found a provisional order. He contended that it would be very much to the advantage of the vestry to entrust the work to some responsible company with the power of purchase at the end of a given number of years. By retaining the power to purchase, the vestry would get all the privileges if the venture turned out a success, and at the same time escape all the disadvantages of possible failure. If Mr. Minchin's proposition were carried, it would simply mean that the better parts of Paddington only would be lighted by electricity, and he (Mr. Judge) would never be a party to any such proceeding. There should be duplicate mains in order to avoid a breakdown, and that provision should be inserted in any agreement they made with any company. As to the suggestion of Mr. Minchin's that they could get a provisional order at the commencement of November, he (the speaker) felt that the matter was of too important a character to be settled off hand in such a quick manner. Even if he were in favour of the vestry doing the work themselves, he should hesitate to ask for an order in the coming session, no other vestry had done so. (A voice "How about St. Pancras?") St. Pancras has done nothing and is in the same position as we are, *i.e.*, they are considering what they shall do before next Session. Continuing, Mr. Judge said he thought the time had come when the vestry should decide to have the electric lighting of the parish done by private enterprise, and to have the different companies competing for the supply. The only way to deal with the question was to get a definite specification of what they wanted, and then let those companies that liked send in their estimates. Let them have a provisional order and put in it all their requirements, and then advertise for sealed tenders.

Mr. Mills seconded the amendment. He regarded the right to purchase at the end of 21 or 31 years as a very important matter. He thought they would all agree that for the next 10 years at least electric lighting would be, to some extent, in its experimental stage, and that would be the same whether the lighting was carried out by themselves or by a company. He should say that the wisest thing for them to do would be to put the work into the hands of persons who had made electricity their special study, and who would be interested in making it a success. He could not see but that there was a great financial risk involved in the vestry doing the work themselves. There was no doubt that electricity would be the light of the future, but perfection in the matter had not by any means been, as yet, attained; and he doubted, therefore, whether the ratepayers of Paddington were prepared to authorise them to embark in a business with their money, and at their risk. If the question as to whether the vestry should do its own paving required many years consideration, surely they should hesitate before they decided to risk the money of the ratepayers in the electric light?

Mr. Whur agreed with the amendment, in so far that he thought it was desirable that a private company should be asked to undertake the lighting; but he submitted that at that early stage it was impossible for them to lay down the lines upon which they would allow a company to come into the parish. They should first pass a resolution adopting in principle the advisability of allowing private enterprise to carry out the electric lighting of the district, and afterwards they could talk about the conditions. The vestry should be very careful not to embark themselves in such an enterprise, which at the present moment was of a purely speculative kind. They were not sent there as practical workers on technical matters, but only to superintend the practical administration of the parish, and they could not possibly know as much about electric lighting as persons did who made it their whole business. If the vestry came to the determination to do the electric lighting of the parish on their own account, he should take steps to obtain the sense of the ratepayers as to the advisability of spending their money in such a way, as he believed that a very considerable majority would be against any such scheme. He appealed to Mr. Judge to withdraw the last part of his amendment.

Mr. Clark supported the amendment, and said he hoped the vestry would seriously pause before they committed themselves to the adoption of a scheme which was of so speculative a character. By retaining their right to purchase the undertaking at the end of a certain term the vestry would get all the advantages of the light without running any risk.

Col. Blair thought the vestry ought not to do the work themselves, because as yet the electric light was only in its experimental stage. He should prefer the appointment of a small committee to watch the progress of electric lighting. Let them see what other persons were doing, and obtain the benefit of their experience.

Mr. Chapman also supported the amendment, as he considered that some of Mr. Minchin's figures were fallacious.

Mr. C. See hoped the vestry would agree to the motion. In his opinion electric lighting had passed the experimental stage. It was clear from the speeches that had taken place that day that the majority of the members had not studied the question, for he was quite certain that had they done so they would have arrived at a very different conclusion to what they had.

Mr. Judge having consented to withdraw the latter part of his amendment, the Chairman submitted it to the meeting, with the result that 24 voted for and only 6 against.

On the motion of Mr. See, the debate was adjourned till next Thursday.

THE ELECTRIC LIGHTING OF THE SAVOY HOTEL.

THE lighting of hotels, restaurants, clubs, &c., in London by means of electricity is gradually being developed on a large scale, and this is not surprising when the great advantages which the electric light has over gas are taken into consideration, one great point being the almost absolute immunity from the danger of fire in such places. Many of these establishments in the metropolis, and a few in the provinces, are already lighted electrically, the current being in some instances supplied from a central station, whilst in other cases the necessary plant has been installed on the premises to be illuminated. Probably the most complete and most efficient—if not the largest—electric light installation of its kind is that which has just been finished at the Savoy Hotel, on the Thames Embankment. This magnificent building, which is scarcely out of the hands of the contractors, is eight storeys high, and occupies a large area of ground.

The boiler house is located in the basement on the western side of the hotel, and contains four large boilers on the Livet system. Two of these are of the Lancashire type, 27 feet long by 7 feet 2 inches in diameter, the other two being Cornish boilers, 27 feet long by 5 feet 6 inches in diameter. They are made for a working pressure of 150 lbs. to the square inch, but are usually only operated at 120 lbs. The steam from these boilers is conveyed by means of large main pipes to the engines driving the dynamos, to pumps and other engines to be referred to subsequently. The engine room is also in the basement, and occupies a space of about 90 feet long by 50 feet wide, this allowing of plenty of spare room. There are in all four high speed compound central valve engines of the Willans vertical type. Three of these are of 160 I.H.P. each, and run at 350 revolutions per minute, whilst the fourth is of 75 I.H.P., running at 400 revolutions. The main steam pipe, which is carried overhead close to the ceiling, runs at right angles to the engines and dynamos. A branch pipe for the supply of steam to each engine is connected to the main; thence to a Boys separator, from the top of which the branch is led to the starting valve of the engine. By this means all condensation is intercepted and a supply of dry steam is ensured.

Four dynamos are installed, all of them being of the Siemens type. Three of these run at 350 revolutions with an output of 900 ampères at 110 volts pressure, whilst the fourth runs at 400 revolutions, and has an output of 450 ampères, the E.M.F. being 110 volts. In each case the dynamo is coupled to the crank shaft of the engine and driven direct from the flywheel of the engine; and for this purpose each dynamo and its corresponding engine are securely bolted to a large cast iron bed plate, the foundation being composed of concrete. The small engine and dynamo are mainly run during the daytime for the purpose of supplying current to the glow lamps fitted in the basement, at the bottom of the staircases, in the offices, &c. One of the large dynamos is retained as reserve, whilst the remaining two, which are run in parallel, are worked in the evening and night for supplying current to the lamps in various parts of the hotel and to those installed in the Savoy Theatre. (It may here be mentioned in parenthesis that the dynamos formerly employed for the lighting of this theatre were taken away, and the theatre supplied from the new machines without the slightest interference with the lighting.) An electric motor of about 4 H.P. has been erected in the engine room for the purpose of driving a fan for the ventilation of the engine and basement rooms.

The hotel has its own supply of water, which is obtained from an artesian well, the mouth of which is in the engine room. The well is 420 feet deep, and for 200 feet the boring is through chalk. On the roof of the hotel is fixed a series of water tanks, and a plentiful supply of water is raised to these by means of two triple sets of 5-inch pumps and two 8 H.P. horizontal engines arranged in duplicate. There are also two large Worthington compound pumps for pumping water for the hydraulic lifts or American elevators, of which there are six. Four of these are for luggage, &c., whilst the other two, which are 8 feet square and have beautifully furnished cars, are for passengers. There are provided four large heaters, each about 4 feet in diameter and 16 feet high. These are for heating, by means of the exhaust steam, water for general purposes, baths, &c., for warming the building in winter, and for providing hot feed water for the boilers. This explanation will now make clear our reference to "other engines" in a preceding paragraph.

Returning to the electrical part of the subject, we will first deal with the switchboard. This consists of a large marble slab about 5 feet square, which is fixed on the eastern side of the engine room. There are five main switches, one being for each dynamo and one for the control of the theatre lighting. In addition to these, there is one switch to each circuit in the hotel, there being in all eleven circuits. On the board is also fixed a Miller ammeter for each dynamo and one for the theatre; also voltmeters, and the usual safety fuses. There is a Schückert voltmeter placed on the wall close to one of the dynamos, so that the attendant may at any time see the pressure without going over to the switchboard. It is proposed to put up a similar voltmeter for each of the other three dynamos. At the side of the switchboard are placed five series of resistance coils, one being for each of the four dynamos, and the other for the motor already mentioned.

The mains, which are well insulated, are carried throughout the building in wooden casing, whilst the branch conductors are let in the walls just below the cornices and are protected outwardly from damage by wooden covering. On each landing there is installed a local switchboard having two circuits. There are also two circuits for the corridors, so that if desired only one half of the lamps need be lighted. The number of lamps—which are in parallel and of 16 C.P.—fitted up in the hotel is about 2,000, and there are 1,000 installed in the theatre. In addition to the 2,000 lights in the hotel there are put up 11 Sunbeam lamps of 200 C.P. each. Four of these are placed in the carriage entrance—two at one end and two at the other—to the courtyard; whilst in the courtyard itself five are put up, two being placed in the centre of the yard over a fountain which is about completed. The remaining two Sunbeams are put up at the embankment entrance to the hotel.

The lighting of the dining, sitting, bed and other rooms in the hotel has been carried out in a most efficient manner, and with due consideration for the wants of those persons using the establishment. In certain of the rooms on the ground floor the lamp fittings are made of hammered iron, and the shades are of fancy glass, semi-elliptical in shape. On the staircases, and in the corridors, the fittings are principally of copper and brass, the vertical glass shades being cylindrical, with open ends. The lamp fittings in the bed and sitting rooms are also of copper and brass, but the shades are globular in shape, and are covered with fancy silk. In each of these rooms is fitted a switch, by means of which the occupant can put on or switch off the current when desired. One remarkable feature of the installation is the fact that in nearly all of these rooms is installed a portable electric lamp with a fancy brass or copper standard, and having about 12 feet of well insulated flexible conductor. We are informed that it is the intention of the company owning the hotel to put up on the south side of the roof, facing the river embankment, the words "The Savoy Hotel and Restaurant." The letters will be made several feet in height, and will be entirely composed of incandescent lamps, so that a very bold effect will be obtained. It is estimated that the number of glow lamps required for this purpose alone will be about 600. The installation has been carried out by Messrs. B. Verity and Sons, of King Street, Covent Garden.

INTERNATIONAL CONGRESS OF ELECTRICIANS HELD AT PARIS, 1889.

(Continued from page 339.)

DYNAMO-ELECTRICAL MACHINES.

Report of M. Hillairet, *Engineer and Constructor.*

At present we designate by the name of dynamo all induction machines, whether of continuous or alternating currents, in which the inductors are constituted of electro-magnets.

It is more than 20 years since Varley and Wheatstone made known simultaneously the principle of self-excitation proceeding from the permanent magnetism of the inductors, and since Werner Siemens gave the name of dynamos to the machines whose inductors were excited by the total current of the armature; but it was not until 10 years ago that the construction of dynamo-electric machines became developed to any considerable degree.

The Gramme machine, the origin of which dates as far back as 1869, and the Heffner-Alteneck machine, which followed it about four years after, were the first machines called *continuous current machines*, capable of rendering service in the industrial world at the outset, and the principles which guided these first inventors in the choice of windings are those which still serve as bases in the greater number of the machines of the present day.

Until 1878, the applications of dynamo-electric machines were very restricted, and met with little encouragement, owing to the limited uses that people could make of them; but at this time the first attempts at the feeding of a number of lamps from a single source having been realised with some success by means of alternating current machines, a new path was naturally opened up for the study of methods of distribution applicable to continuous current machines, and the employment of distribution in series, first developed itself. Some time after, the appearance of the incandescence lamp caused a reaction in its turn, and developed the application of distribution in parallel or derivation.

Progress was so rapid in the two years that followed 1878, that it was deemed necessary in 1881 to consecrate specially to electrical science and industry a Congress and an Exhibition, to which we owe a large proportion of the present developments of the construction of dynamo machines. When we look back and consider with what simple means the first machines were realised, we are astonished that such elementary construction could give such remarkable results. However, as with comparatively limited power the speeds of rotation were generally considerable, the absolute value of the efforts was always somewhat low, and the organs had sufficient resistance for the wear required of them.

At this time the diameter of the armatures of the best known dynamos rarely exceeded ·2 of a metre, and the maximum effort at the periphery of these armatures hardly amounted to 20 kilogrammes.

But when fresh requirements were developed, and constructors saw themselves compelled to increase the individual power of the dynamos, it became necessary to abandon the paths followed up to that time, and it was not without difficulties of all kinds and failures also that in a little time powers were arrived at, that were comparable to those of the most powerful industrial generators, and dynamos were realised whose motive momentum would not be brought into equilibrium by suspending a weight of 1,000 kilogrammes at a distance of one metre from the axis. There was, before the appearance of actual types, a period of transition which it would be difficult to characterise briefly, and during which empiricism yielded little by little to a methodical application of the most elementary principles of induction and of the laws of magnetism, whilst the process of construction was modified and gave rise to the evolution *which we are now seeing accomplished.*

It is by rigorously observing the fundamental theorems of electro-magnetic induction that we have been enabled to begin to explain in a satisfactory manner the working of the machines of the present day, and it is through having neglected what has been known since 1831 that, during about half a century, the greater number of inventors failed in their attempts.

By considering inductive apparatus as true machines which could not be submitted to the common law, and in which it was necessary to know above all, how to estimate and improve the economic coefficient, the first step was made in a path which would necessarily be fruitful since it was natural. The application of the principle of the conservation of energy enabled the working of the electro-magnetic machines in its entirety to be examined with facility, as it had already suggested other happy conceptions in the domain of physical theories.

The observation of the law of proportionality of electromotive forces to the flow swept by the induced circuit in the unit of time, and that of the principle of the equivalence of windings of the same volume were the first object of research and improvements.

The popularisation of these essential ideas is certainly due to the efforts of the International Congress, and it was really at that time that the construction of continuous current and alternating current machines began to be freed, little by little, from barbarous methods and from empiricism to proceed methodically and successfully. In 1879, Dr. J. Hopkinson, studying experimentally the value of magnetic induction in the armature of a dynamo as a function of the exciting current of the inductors, made use of a curve representing the phenomena, to which later the name of *characteristic* or *curve of magnetism* was given. M. Marcel Deprez in 1880 developed the geometrical properties of the characteristic and established the fundamental rules which must above all be satisfied by the characteristic of a given machine, according to the object proposed: the transformation of windings, distribution in derivation or in series.

Almost at the same time Dr. Frölich, who was studying the same questions, established an empiric function representing the action of the same phenomena, the form being borrowed from a function which had already served to represent the variations of the magnetic moment of a bar of iron according to the variations of the exciting current.

Although, at that time, M. Frölich's formula, and also the conclusions that he drew from it, rendered some service, it was destined to lose its importance beside the results at which the recent researches on magnetic induction have enabled us to arrive.

In 1885, Messrs. Hopkinson communicated to the Royal Society in London an article relating to the approximate determination of the magnetising force as a function of the different values of the magnetic induction in the armature, and containing theoretical developments, accompanied by most valuable experimental results. At that time, the necessity of improving the machines, and giving a logical basis to their establishment, gave rise to some studies on the same subject, based on ingenious hypotheses, some of which were by no means new. Although these studies rendered some service, and are admissible within certain limits, it is incontestable that Messrs. Hopkinson's article should be appealed to in preference, since it shows us, in a satisfactory and logical manner, how a method of calculation for dynamos can be deduced from the geometrical propositions of Green, Poisson and Laplace, and from the physical experiments of Maxwell, Sir W. Thomson and Rowland.

These researches sufficiently complete the earlier studies to enable us to undertake with exactness the study of continuous current machines, the establishment of which can now be effected with a degree of precision rarely met with in the construction of other industrial machines.

The development of alternating current machines followed that of continuous current machines, and benefited by the researches we have mentioned. But in these latter there is a variable action which is difficult to seize and specify, resulting from the induction proper or self-induction, and from the mutual induction of the different circuits, and the presence of this action still necessitates the use of quantities or coefficients, the physical nature and the value of which are not sufficiently defined or determined.

The definition and determination of the rendering are elements that it is most important to consider in the theory and practice of dynamos, seeing that its interpretation has often given rise to errors and misconceptions.

The gross rendering of a dynamo is the ratio of the electrical energy obtained at the terminals of the machine to the total mechanical energy expended.

The determination of the rendering, which may be effected simply and with great precision in continuous current machines, offers some difficulties in alternating current machines. In order to avoid all misconceptions in this last case, and eliminate many errors in experiment, it is desirable to remember that the available electrical energy can easily be collected at the terminals under the form of heat, and that we can deduce from the study of the phenomena of incandescence a simple and sensible mode of procedure for measuring the electrical elements of continuous current machines, and determining the absolute value of the rendering.

The first induction machines constructed for industrial purposes were intended for supplying voltaic arc lamps. It was to this application that the first efforts were directed, to which we owed in succession machines with periodic, alternating or commutated currents, machines with currents always of the same nature, and so slightly undulatory that they may practically be considered as continuous; and, finally, the machines on which a certain number of lamps can be grouped at once.

The realisation of the independence of the lamps fed from the same source has given rise to researches and results which have a direct relation to the studies already mentioned; it is thus that the play of the magnetic actions has been utilised to obtain the regulation of the elements of the distributions fed by machines whose inductors are excited according to different methods. It is well to remember and note that it was owing to the simple and easy regulation by inductors with mixed or compound winding that the first electric lighting installations were developed, and particularly lighting by incandescence lamps, which, until this method was produced, seemed to depend exclusively on dynamos with derived excitation and armatures of very low resistance. The establishment of central lighting stations may be realised according to two perfectly distinct methods, according to whether the system which it is required to supply be extensive or limited: the distribution may be effected directly by the current of the machines at the station or indirectly by a transformed current. The primary distributions, by their very nature, are evidently more limited in their applications than the others. The machines employed in this method differ in little else but power from those in use in private installations.

The distributions of a secondary character and their congeners, with all the combinations of systems and regulating apparatus to which they give rise, are evidently the methods that will prevail in the future, and it would be impossible to determine now the practical limits of the most extensive system that they would be capable of supplying.

It is to the creation of secondary distributions that we owe the present development of alternating current machines constructed for the feeding of transformers by mutual induction, which now seem to be more in request than continuous current transforming apparatus.

The first experiments in the electrical transmission of mechanical work by the reversibility of the work of the induction machines date almost from the appearance of the first industrial types, and have become classical.

Electrical transmissions can be divided into two categories, according to whether we utilise merely that property of electrical energy of being capable of transmission from one place to another by conducting wires easily arranged, or certain properties of electrical motors which we should seek for in vain in other industrial motors.

This last category of electrical transmissions already numbers several applications, whereas the number of transmissions to a great distance is as yet comparatively limited. It is true that these latter, to be economical, ought to be arranged for working at high tensions, and that the use of these tensions presents some difficulties; moreover, the number of cases in which these transmissions can be applied with advantage is, for many different reasons, not so high as might at first be imagined. Nevertheless, in this respect also, we note that important progress has been made, and we can also report the satisfactory working of certain transmissions, the establishment of which would, a few years ago, have been looked upon as impossible. It seems undoubted now that we can almost with certainty avoid the greater number of accidents that stopped the development of the first machines with a high electromotive force. If we had succeeded earlier in acquiring the knowledge that we now possess of the phenomena which characterise the action of these machines, and of the necessary qualities of the insulating materials required, the Congress would have had to report and study not a few isolated examples of transmission to a great distance, but a whole system of applications, of which we can as yet neither appreciate clearly the tendency nor measure the economic value.

The processes of distribution in use in lighting installations are also employed in electrical transmissions; in either case there is the desideratum of effecting distributions directly under great differences of potential without having recourse to the intervention of secondary apparatus or transformers, which always deduct a considerable fraction of the energy transmitted as the price of the transformation.

When we see industries procuring from a distance the work of their factories, increasing their plant, modifying their processes, and developing their means of transport by the help of electrical energy, we cannot help recalling the judgments passed formerly, which seemed to condemn irrevocably the use of electric motors. In 1839, in fact, after the trials of Jacobi's boat on the Neva, it was declared that *evidently electric motors would never take the place of the steam engine in industry*, and the committee nominated by the Germanic Diet, in 1845, to examine the Wagner motor solemnly concluded that *no good result could be expected from the application of electro-magnetic force to mechanics as compared with that of steam.*

The multiple applications of electrolysis owe their present development simply to the employment of dynamos, which, in their turn, have had to be adapted to the requirements of electrolytic operations.

If the indispensable employment of high electromotive forces for transmissions to a great distance necessitates a special study of dynamos with fine windings and low output, it is quite otherwise with dynamos intended for electrolytic operations, which are in general characterised by their low tension and high output.

The *savants* who frequented the workshop of Père Hippolyte Pixii introduced there, in 1831, the principles of induction, and it was with a Pixii machine that Ampère effected for the first time with an inductive apparatus the electrolysis of water. This experiment may be considered as the first application of machines to electrolysis, the origin of which dates as far back as 1832.

This fact is of purely historical interest, for it was necessary to wait until the cost of electrolysis was considerably lowered by the increase of rendering of the machines, before it could be applied to industrial operations.

The first applications of importance related to the refining of copper, and consequently involved the less critical of the electrolytic operations. The power of the machines now in use has enabled us to enter upon the complex and costly reactions of electro-metallurgy, in which the electrical energy is utilised at the same time under the form of heat, and also as the agent of separation; thus, besides electrolytic treatment in a liquid medium, we have developed treatment by means of fire, to which we already owe some products.

In brief, whether we are considering lighting, transmission, or electrolysis, if it is difficult to define the present position of the applications of the dynamo to these three branches of industry, it is still more difficult to foresee or to indicate the limits of future applications, of which we can scarcely form an idea, even if we substitute, by the simple method of equivalents for heat and mechanical work, electrical energy under its different forms.

ELECTRIC LIGHTING.

Report of M. HIPPOLYTE FONTAINE,

Engineer and Administrator of the Gramme Magneto-Electric Machine Company.

Electric lighting, in its various modes of production and employment, would necessarily occupy a prominent place in the programme of the new Congress, for there are in existence few electrical industries so important from the triple point of view of the capital engaged, the variety of systems in action, and the number of applications realised.

In fact, from the last documents submitted to our consideration, it seems that at the present day there is a motive power of nearly a million H.P. converted into electric light, corresponding to a total intensity of about 200 millions of normal candles; that the number of central stations exceeds 1,500, and that of private installations 10,000; and, lastly, that the capital sunk in electric lighting amounts already to more than a thousand millions of francs. The most characteristic fact that we can mention after this prodigious development is that the United States alone possess as many electric lights as all the rest of the world.

The first practical and permanent installations were made in France during the winter of 1874-5, in several workshops in Paris, and in some provincial factories, by means of continuous current dynamos and monophote regulators.[*]

In 1878 the candle and the regulators in series introduced the employment of the voltaic arc into shops and public streets—then, in 1880, incandescence lamps made their appearance and gave electric lighting the *entrée* into private houses and all places to which the great intensity of the arc was not suited.

A French firm exhibited in 1876 at Philadelphia some dynamos and electric regulators, the working of which was irreproachable—fixity of light, regularity of action, economy of production, facility of maintenance; nothing was wanting. There were not in existence then, either in the Exhibition or in Philadelphia, or even throughout America, any other apparatus capable of giving a result comparable to this (the voltaic arc was sometimes employed for luminous projections, but never for permanent lighting). Twelve years later, in August, 1888, the official statistics of the United States showed that power amountiug to 459,000 H.P. was utilised in the production of electric lighting. This proves that France was the cradle of the electric lighting industry, and that the United States are a grand country where ideas germinate and fructify with astonishing rapidity. Electric lighting is developed quickly in a country where the want of lighting is great, where public works create less hindrances to the employment of currents of tension, and where the cost of the other systems of lighting is high.

In 1878 gas was very dear in all the large towns of the United States, and the gas companies did not possess the unheard-of privileges that they enjoy in France. The need of artificial lighting was considerable; electricians, being favoured by a very liberal administration, were able to establish overhead cables everywhere and use currents of very high tension. Moreover, as soon as dynamos and electric lamps had taken a sufficiently practical form, the American inventive genius and commercial instinct were able to launch out freely; installations multiplied and marvellous improvements arose as if by magic. The gas companies, finding their interests seriously compromised, modified their methods, lowered their tariffs, and endeavoured to obtain an increased sale otherwise than by lighting. But, fortunately, gas was able to keep its position without injuring electricity; in the United States, where there is little coal, wood and anthracite abound, so that fuel is cheap and gas comparatively dear.

Paris, to take a point of comparison in Europe, is a town where æsthetics play a considerable part, where gas companies possess great privileges and share their profits with the town, where police regulations are opposed to all innovations, &c. We can understand that, under these conditions, it would have been very difficult for the City of Paris to have benefited by electric light installations like New York, Philadelphia, Boston, &c.

It will come, no doubt; a great movement seems to be in preparation in this direction, but what is in existence in Paris at the present day is not to be compared with what we find in the great American cities.

Classification of Burners.—The lamps at present in practical use may be divided into four classes:—

1. Arc regulators with carbons facing one another.
2. Candles with parallel carbons.
3. Ordinary incandescence lamps.
4. Incandescence lamps of great intensity.

These various forms are not used exclusively for certain purposes; the choice between them depends generally on the dimensions of the spaces to be lighted; they are often combined together in important installations.

Regulators.—The voltaic arc regulators have the great advantage of producing a very intense light with a small expenditure of electrical energy. The employment of them has been greatly developed in public installations, especially in the United States, where they are used for lighting whole towns; in State factories and private workshops, where we always find competent persons to superintend them; and in the service of both the army and navy, where they are utilised with equal success in operations of attack and of defence.

It is true their mechanism is easily put out of order, but this inconvenience is now almost overcome, owing to the progress made in the study and manufacture of the apparatus.

It is urged against them that they require daily attention as regards the replacing of the carbons, which, when the apparatus is not easily accessible, is inconvenient, difficult, and sometimes dangerous. But this case is rarely met with in practice now. The greater number of regulators are fed by currents of about 70 volts at the terminals of the dynamo, and only 45 to 50 at the terminals of the lamp. The fall of potential between the two apparatus arises from a metallic resistance introduced between them. Without this resistance, which often absorbs more than 30 per cent. of the available electrical energy, the light is irregular and disagreeable and subject to frequent extinctions.

The problem of doing away with this intermediate resistance has already received several solutions more or less practicable, and more or less complete, but none have as yet been adopted to any extent in public or private installations.

The great interest that this question presents from an economical point of view will certainly draw upon it the attention of the members of the congress.

The *monophote* regulators, which can only be placed singly or in derivation on the same circuit, generally give a very steady and regular light. They are employed successfully in France, England, and several other countries of Europe.

The *polyphote* regulators, arranged in series, are installed very economically, as they can be placed upon conductors of very slight section. In public services this is a considerable advantage, the price of conductors being very high as compared with the other parts of the installation. In the United States regulators of this class are employed exclusively, and as many as 50 are placed on one circuit.

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[*] We do not think that the illumination of certain lighthouses and public works can be considered, properly speaking, as lighting, or we should have dated this period 15 years earlier, still claiming for France the priority of installations.

Candles.—The electric candles with which the *Avenue de l'Opéra* was lighted from 1878 to 1882, have not had the commercial development that was expected from their extreme simplicity. They have for 10 years kept the place which they took at the outset in the large shops; they have succeeded in obtaining a footing in some establishments of the same kind and in a considerable number of factories, but the demand for them has not kept pace with the ever-increasing demand for regulators, and still less with that for incandescence lamps.

The absence of all mechanism for keeping the distance between the points of carbon constant diminishes the cost of installation and imparts to the candle an unfailing regularity of action and a facility in its employment which enables the duties connected with the lighting to be entrusted to persons without any special knowledge. They have also the advantage of being able to be placed on chandeliers of no very great height in globes from ·3 to ·4 of a metre in diameter, whereas the regulators nearly all require available heights exceeding ·75 of a metre.

Lastly, owing to their capability of being clustered together in considerable numbers on the same chandelier, they admit of a long period of lighting without requiring attention.

But, on the other hand, their brilliancy and colour are susceptible of slight variations, which, in certain cases, affect the eyes; their intensity, which is generally from 30 to 50 Carcel burners, cannot exceed 100 burners; their cost price is naturally somewhat higher than that of simple carbons; lastly, they require, with an equal amount of light, a much greater motive force than the regulators.

Ordinary Incandescence Lamps.—Incandescence lamps of from 8 to 20 candles are now in universal use. They owe their immense success to their extreme convenience as compared with all other known modes of lighting, electric arc lights, gas, oil, petroleum, &c.

To light them and also to extinguish them, all that is necessary is to turn a simple switch. Their duration exceeds 1,000 hours when care is taken not to work them at too high a pressure. Their brilliancy is very steady and their light very pleasant.

The only objection that can be urged against them relates to their great consumption of electrical energy, but we think it is mistaken economy to reduce this consumption to any considerable extent, by raising the lamps to an excessive temperature. In fact, the principal advantage of incandescence lamps consists in their long duration, and consequently in the absence of that daily attention which we mentioned when speaking of regulators, and as lamps raised to too high a temperature do not resist the action of the current nearly so long as the others more lamps are consumed. We lose more in the one respect than we gain in the other, and at the same time deprive the lamp of its chief advantage. The lamps which consume 4 watts per candle last easily 1,000 hours on an average, whereas those which only consume 3 watts per candle rarely last more than from 300 to 400 hours.

Incandescence Lamps of Great Intensity—Incandescence lamps of 50, 100, 500, 1,000 and even 1,500 candles and coming into use, in direct competition with the arc regulators.

These lamps, like the other incandescence lamps, last longer and consume more electrical energy when not driven at too high a pressure; and when they are overdriven they last a shorter time and consume less. Thus in each particular case we must calculate whether we shall economise the work at the expense of the lamps, or the reverse.

In the greater number of projects submitted to our consideration, we have found it advisable to use rather more energy and lessen the consumption of the lamps.

Leaving out of consideration the advantages resulting from the absolute steadiness of the lights and the convenience of their use, which amounts to examining the question from the point of view of expense only, we arrive at the following results:—

A regulator receiving an initial current of 8 ampères at 70 volts consumes 560 watts, and practically requires a mechanical energy of one H.P., the cost of which varies according to the locality and the importance of the installation. We will suppose it to be 10 centimes per hour.

If the voltaic arc is placed 4 metres above the ground, we may reckon upon an available luminous intensity of 100 carcel burners and an expenditure of about 8 centimes per hour for carbons.

The replacing of the carbons is generally performed after four or five hours of action, and together with the cleaning of the apparatus necessitates an amount of manual work the cost of which may be estimated, on an average, at 4 centimes per hour.

The total cost of one light, under these conditions, not including interest, waste and general expenses, amounts thus to 22 centimes per hour.

An incandescence lamp of 100 carcels costs 40 frs.; it lasts on an average 400 hours when the expenditure is 2½ H.P., and 1,000 hours with an expenditure of 3 H.P. The cost per hour is 35 centimes in the first case and 34 in the second.

If the cost of attendance and of the carbons rises, or if that of the motive power falls, it may happen that the incandescence light costs less than the arc light. This is what almost always happens when waterfalls are used to work the dynamos.

The necessity of replacing the carbons every day in the arc regulators is the principal cause of the inferiority of these lamps to the large incandescence lamps; it will perhaps one day lead to the latter entirely superseding regulators of small and average intensity. The manual work is in fact not only a source of expense, it is an obligation that often entails great inconvenience.

Central Works.—The working of the central stations varies according to the amount of lighting required, and the nature of the currents and lights employed.

If we except the works that supply the candles in the port of Havre, we may state that until lately continuous currents were the only ones used in central stations. But during the last few years, alternating currents have come into favour, and large installations have been established in which they have been employed.

In Europe, the incandescence lamp is used almost exclusively by municipalities and for private establishments; in America, arc regulators and incandescence lamps are both used, and are often to be seen in the same installation.

Continuous Current Works.—When incandescence lamps are used, these lamps are supplied directly by the circuits of the dynamos, or indirectly by the intervention of accumulators. The direct supply is generally effected at the present day according to the following principles:—The dynamos are each worked by a special motor, or arranged two upon one motor. Each of these pairs forms one complete group, and the system consists of a variable number of these groups. (The employment of a very powerful motor, working a certain number of dynamos, has the disadvantage of not working economically during the greater part of the day, owing to the variations in consumption).

The supplies of currents to consumers are effected by a system of conductors passing through all the streets, and forming a veritable network. This system is supplied by main conductors, on which no derivation is taken, and for each of which the loss of charge, independently of the length, is the same.

The difference of potential is thus kept constant at all the points where the branch conductors are joined to the principal conductors, so that from these points uniform secondary currents flow, so to speak.

The system with three conductors, working with the grouping of the dynamos in pairs, and the union of all the dynamos at the works upon strong bars of copper, from which proceed the main conductors, also constitutes two points essential to this mode of installation. When arc regulators are used, similar arrangements can be employed, especially when the spaces to be lighted are concentrated near the dynamos; but when it is required to light a town or a vast work-yard, distribution in series becomes necessary. Then distinct circuits are employed, each supplied by a special machine.

Works with Accumulators.—At first, accumulators were used as reservoirs of electricity. A certain number of batteries were introduced along the line, and constituted secondary stations. These stations comprised two batteries each; the one being charged from the system, the other, independent of the system, discharging upon the lamps. Every day these batteries are changed, the one taking the place of the other.

Subsequently the rôle of the accumulators was reduced to that of regulating flywheels. For this purpose they were placed in series along the line, and from the extremities of each battery, conductors proceeded, forming a local circuit, which was connected to the lamps. In this system the accumulators become charged during the periods when the consumption of light is very slight and they discharge, adding their current to that supplied directly from the works, at the time when the consumption is at its maximum.

Lastly, in some more recent installations the accumulators are removed automatically, one by one, from the battery and introduced each in its turn for a few minutes into the line where it becomes charged, the others discharging upon the circuit of lighting. The charge is effected under a constant current by means of a dynamo worked by a steam motor, the speed of which is regulated automatically, so as always to ensure the fall of potential suited to the maintenance of this current.

Alternating Current Systems.—The works using alternating currents only differ from one another by the mode of employing the dynamos and the manner in which the primary and secondary systems are constituted.

In order to make the production meet the consumption when the latter is increased, we add to the service in succession dynamos which remain inactive when the demand is not so great, or else substitute a more powerful machine for the one already working. We may also, with the same view, form the distribution into several distinct systems, connect these systems together at times when the consumption is not very great and separate them, allotting a special machine to each when the consumption is at its maximum.

Lastly, at important stations, the machines are so constructed that it is possible and easy to connect them in derivation upon the principal outgoing cables. There is then no difficulty in suiting the production to the expenditure; the distribution is effected, as in a continuous current system, by the successive addition of complete groups.

The distribution by transformers is effected in derivation; nothing has come of the attempts made with a view to grouping in series. As it is easy to reduce the loss in the primary line as much as is required, these apparatus generally branch directly from the principal circuit; but if the number of these were considerable and the system very extensive, the same arrangements would be made as in continuous current stations.

The transformers are placed either in sheds or outside the station on supports fixed to the walls, or upon the posts that support the wires.

As to the secondary system, it is utilised in two ways: sometimes each consumer or group of consumers is supplied by a single transformer having no connection with the others; sometimes all the transformers are connected into a common system to which all the conductors of the consumers are attached.

Comparison.—The respective advantages and disadvantages of the various modes of working have given rise to very animated discussions which we will briefly sum up.

Continuous currents lend themselves readily to the sale of the motive power, to electro-chemical decompositions, and seem favourable to the supply of regulators. Their defects are having a limited radius of action owing to the expense of the conductors and losing a great quantity of energy in the system. Alternating currents, on the contrary, have a very extensive radius of action and give rise to very insignificant losses of energy; but they cannot be used for chemical decomposition, and are ill-suited for distributions of motive power.

The distributions by means of accumulators have in their favour the almost complete suppression of stoppages; but the material required is cumbersome, expensive, and not durable.

Their radius of action is more extensive than that of direct distributions with continuous currents; however, the economy in conductors resulting from it is far from compensating for the losses arising from the tranformation by the accumulators and overcharges which are almost inevitable.

Conclusion.—In this short notice we have broadly shown the origin of electric lighting, its importance at the present day, the systems of burners in use, and the various modes of working at the central stations.

In order to complete the requirements of the programme, we ought also to have entered into the luminous intensities generally adopted in the various public and private systems of lighting. But we have found so much difference and so many contradictions in the opinions expressed by practical men on this interesting question that we think it best to leave to the congress the task of stating the problem, developing it, and, if possible solving it.

ELECTRICITY: ITS PRESENT, AND ITS FUTURE.

THE Paris *Matin* published on Sunday, under the heading of "Electricity: What it has given us, and what it promises," an interesting interview with M. Hospitalier on the subject of the Congress of Electricians, which has met in connection with the Universal Exhibition. Our contemporary says:—"For some years past the science of electricity has been revolutionising the world. It has penetrated into our social life as well as the experimental sciences, multiplied the relations between the peoples of the world, augmented a hundredfold the resources of man, and will be tomorrow the most potent factor in regard to the civilisation and progress of humanity. We thought, therefore, that it would not be without interest to give a *resumé* of the labours of this Congress, to which, perhaps, by the fact of their technical and scientific character, the general public may have been indifferent. With this end in view, we requested one of our most distinguished electricians, who is a celebrated *savant*, M. Hospitalier, Professor of the School of Physics and Chemistry of the City of Paris, to relate to us what has already been achieved, and what is promised for the future. At the outset, M. Hospitalier reminded us that the Congress, which was attended by more than 600 members, representing the civilised nations of the two worlds, had for its Honorary President Sir William Thomson, one of the most distinguished of *savants*. As M. Mascart, Professor of the College of France, well put it, this meeting of scientists, brought about through the instrumentality of France, was, in spite of Germany's abstention, in accord with a general consensus of scientific opinion. Among the Vice-presidents, for instance, were Edison (United States), Ferraris (Italy), Kareis (Austria), Potier (France), Preece (England), Rousseau (Belgium), Stoletow (Russia), and Weber (Switzerland). On our asking M. Hospitalier to kindly enumerate the results of the Congress which would be the most interesting for our readers, he answered, smilingly:—'But perhaps these results will not interest them in the least, for the subject is somewhat abstract. An effort has been especially made to define the language of electricians, to arrive at an agreement which will obviate any confusion in the future in regard to the study of facts, to create new expressions for new ideas, and to bring about a general understanding as to the employment of terms which represent the units of work, of electrical power, and of motive force, &c. Those are dry questions for the general public, who scarcely trouble themselves about the practical discoveries of electricians. But it is precisely to facilitate our studies, to come to an understanding upon the definition of certain terms, to impart a greater clearness to our formulæ, to render less separable the connection between language and thought, and especially to help forward the practical application of electricity that we met together. I will only quote you two examples. Let us take, first of all, the photometric unit. In France the unit is the *bec* Carcel, a lamp which burns 42 grammes of oil per hour with a flame of 40 millimetres; in England it is the candle or Parliamentary standard; in Germany a candle of paraffin. You will readily understand that under these circumstances *savants* scarcely understand each other when discussing the illuminating power of a source of electricity. The Conference of 1884 made a step forward in reference to this question. It decided that the unit of light is the quantity of light emitted under ordinary circumstances by a square centimetre of platinnm at the temperature of solidification. This is the standard of M. Violle. It was consequently said, speaking of the illuminating power of electricity, one violle, &c., two violle, &c., representing 13 candles, 26 candles. But you will be surprised to hear that these words, one violle, &c., two violle, &c., give the public a wrong impression regarding the intensity of the electric light. It was decided, and rightly, too, at the last Congress, to estimate the intensity of a lamp in candle-power by taking as the practical unit, under the name of decimal candle, the twentieth part of the absolute standard of light defined by Violle. The decimal candle thus defined is practically equal to the tenth of the Carcel lamp. There is another question having reference to politics. It has been decided to describe in telephony by the appellation of *interurbaine*, every telephonic communication passing between two subscribers or public cabins forming part of different groups. That is an agreement which will permit an understanding between the representatives of different nations, which was not always easy, even upon a question apparently so simple. Following the same order of ideas, the Congress designated the practical unit of work, the *joule*, the practical unit of power, the *watt*. Henceforth, in practical industry, the power of machines will be expressed in kilowatts, instead of in horse-power. The Congress also adopted definitions of terms in common use in industrial and telephonic matters. There were, in fact, some very complete and interesting discussions upon accumulators, the establishment of lines of transmission for the telegraphs, motive force, methods of working, &c. In short, its work will be useful to science and to industry, and as we have seen this year the progress that the Congress of 1884 brought about, so we shall see in 1892, the date of the next meeting of electricians, the happy reforms permitted by that of 1889.'

"'Do you think that electricity has some great surprises in store for us?'

"'Ah! on that subject I can conceive nothing but hopes. America is greatly in advance of us from the point of view of the development of the applications of electricity. In America, for example, there are more than one hundred lines of tramways which are being worked by electricity; in France there are not three. In the United States the printing machines are almost all worked by dynamos. The manufactories of distribution do not simply, as in France, ensure the lighting of the streets and of private houses, but they provide also the motive power for a great number of industries. These manufactories can everywhere work during the day, and consequently diminish their general expenses. Moreover, the incandescent lamp has taken in the United States a development that we are far from having reached. There 2,000,000 of lamps are at work; the number here is very far less. I think, however, that if they construct more and more central manufactories working day and night, distributing motive power and light, that would largely favour the numerous applications which can be made of electricity.'"

CONTINENTAL NOTES.

[FROM A CORRESPONDENT.]

SOME important long-distance telephone lines are now being laid on the Continent, viz., between Vienna and Pesth, Amsterdam and the Hague, Rotterdam and the Hague and Schweveningen and the Hague, whilst from St. Petersburg comes news that a syndicate has been formed for laying a telephone line between the Russian capital and Moscow.

From China, too, news of progress is received, the Telegraph Administration of the Celestial Empire having completed the telegraph line to the south-west frontier of the province of Hu Nan, or within some 200 miles of the Burmese frontier, so that eventually the Indian and Chinese telegraph nets may be connected.

An electric light company has been formed in the city of Helsingfors, the capital of Finland, being the first of its kind in that country. The capital is £10,000. A central station will be ready this autumn capable of sustaining 1,200 lamps, but with apparatus for 2,500. The system adopted is the Thomson-Houston transformer system.

An electrical railway, said to be the longest in the world, is being laid at Buda-Pesth by Messrs. Siemens and Halske, Berlin.

The latest international adherent to the European telegraph system is Bulgaria, that state having agreed that express telegrams (télégrammes urgents) may now be conveyed over all Bulgarian lines whether locally or in transit to other countries. Moreover, the French company Société des Télégraphes Sousmarins has joined the International Telegraph Convention as regards the submarine cables Santiago de Cuba, Môle St. Nicolas (Haity), Puerto Plata (Dominique), San Domingo, Curaias, La Guayra (Venezuela).

In Berlin, during recent years, the electric light has made undreamt of progress in the leading thoroughfares. In consequence the central stations have had to be enlarged. The stations in Markgrafenstrasse and Mauerstrasse now boast 4,000 horse-power, capable of feeding 40,000 glow lamps. In addition, this autumn two more stations are to be erected, each working with 2,000 H.P. The existing stations are also to be enlarged, so that in three years' time the Berlin stations will possess a force of 14,000 H.P., capable of feeding 150,000 lamps. It is claimed that in no city in Europe has the electric light spread so rapidly as in Berlin. In one part of the city there are now more electric lamps than gas jets, although the latter have not diminished. Electricity is also becoming extensively used as a motive power. Thus many large public assembly rooms, cafés, &c., are now being ventilated by electric motors, whilst several sewing-machine establishments are similarly worked. Naturally the larger the consumption the smaller the cost, and it is therefore anticipated that the cost of electricity will soon be further reduced.

As a matter of curiosity it may be mentioned that at an hotel in Turin the electric current used in lighting is also used in heating a grid-iron for the cooking of chops, steaks, &c., with the greatest success, the bars being of steel wire.

The latest great event in electrical history in Sweden is the opening of the telephone between Stockholm and Gothenburg, an undertaking to which we have previously referred. The distance is over 500 kilometres, and nearly the whole of southern Sweden is thereby connected by telephone. There are two double-wired copper cables, the whole plant having been manufactured in Sweden, and conversation is carried on without the slightest external noise or disturbance; in fact, there is much less of the latter here than on the single lines within the capital itself. By connecting other systems conversation has been carried on over a distance of 1,000 kilometres with equal success. The wires are laid upon the ordinary telegraph poles. However, at present there is only one terminal station at each end, which retards business somewhat, but soon all State telephone and telegraph stations along the route and at both ends will be connected with the new trunk lines. The charge is 4d. per 100 miles for a three minutes' conversation and 6½d. above, with an extra 1½d. per minute.

From the report just issued of the Norwegian telegraphs last year, it appears that 1,252,300 messages were transmitted, as against 829,496 in 1887, being an increase of 74·3 per cent. on the home and 22·4 per cent. on the foreign service. The correspondence was largest with this country, viz., 29,988, against 25,800 in 1887. The greatest foreign correspondence occurred in the month of August, the smallest in January. The gross receipts amounted to £52,700, against £46,000 in 1887, being an increase of £6,700; but, nevertheless, the expenditure exceeded the receipts by £6,000. There were 149 telegraph offices in operation. The length of main lines December 31st was 7,486 kilometres. The *employés* numbered about 500, 90 being ladies.

A foreign contemporary writes respecting lightning:—"The lightning flash is rarely purple, but most generally white, blue or yellow, and it would appear from observation that the white and chintz-white flashes are the strongest and least inflammable, whilst the yellow and reddish are weaker and more so."

The alleged illegal seizure of the Paris telephone company's premises is not yet done with, as we learn from Paris the company, acting on the advice of M. Roger-Marvaise, *avocat* to the Council of State, is going to appeal to the latter body against the Ministerial warrant of expulsion of this company, and which, according to the terms of the appeal, constitutes a veritable spoliation.

The second meeting of the Electrical Committee for the examination of the tenders relating to the electric lighting of Brussels and the establishment of a central station, took place on Friday morning last at the Hôtel de Ville. The Committee continuing its labours separated without coming to any decision and were to meet again. It is probable that after this third sitting the Committee, having heard enough evidence, will make a choice between the propositions submitted to it.

According to the Berlin correspondent of the *Indépendance Belge*, Mr. Edison was as heartily welcomed in that capital as he was in Paris. This correspondent says: The *Independance* has for a long time called attention to the astonishing discoveries of Menlo Park, and I will now limit myself to the details of his visit to Berlin. Instead of troops on parade, Mr. Edison was shown things which interested him much more; scientific institutes, new apparatus and complete installations. He was agreeably surprised at visiting our electrical installations which he did not expect to find so large. He did not expect to find his inventions applied in Berlin more largely than in his own country. He especially admired our steam engines and dynamos, the power of which is up to 1,000 horses, while the American machines do not exceed 200 horses. Mr. Edison spoke of the beauties of Berlin, the organisation of its sanitary and public health services, not hiding the fact that in many respects Berlin pleased him better than Paris. What will the directors of the *Petit Journal* say, who have taken his journey to Berlin in such bad part? Will they lynch him on his return to Paris some of these days? He was much pleased with his reception and as a recognition he promised the Institute two improved phonographs. I had the pleasure of assisting yesterday at a private dinner given to Mr. and Mrs. Edison by Herr Rathenau, director of the Allgemeine Electricität Gesellschaft, and on conversing with the great inventor, found him a true philosopher, very simple and without pretensions.

NEW PATENTS—1889.

13795. "To turn artificial and natural light, even plane atmospheric light, into an electrical current." P. von Knobloch. Dated September 2.

13800. "Improved supports of secondary batteries." G. E. Heyl. Dated September 2. (*Complete.*)

13834. "Improved means and apparatus for producing electricity for electric lighting and other purposes." W. Boggett. Dated September 2.

13838. "Improvements in means or devices for use in the distribution of electrical currents." A. W. Heaviside and R. C. Jackson. Dated September 2.

13841. "A new and useful telegraphone." M. Wheless. Dated September 3. (*Complete.*)

13864. "Apparatus for automatically charging secondary batteries or accumulators." S. C. C. Currie. Dated September 3. (*Complete.*)

13955. "Improvements in transformers for continuous electric currents. A. Bernstein. Dated September 4.

13956. "Improvements in the manufacture of incandescent electric lamps." J. Greenwood. Dated September 4.

13960. "Improvements in and relating to apparatus, chiefly designed for measuring electric currents." A. L. Shepard. Dated September 4.

13990. "Improvements in electro-magnetic apparatus for automatically opening and closing passages for gases, liquids, and the like." J. R. Schiller and C. Meyer. Dated September 5.

13992. "Improvements in electrical switches." A. Slatter. Dated September 5.

13993. "Improvements in electrical safety-fuses." G. E. B. Pritchett and H. R. Low. Dated September 5.

14011. "Improvements in switches for opening and closing electrical circuits." A. L. Shepard. Dated September 5.

14017. "Improvements in conduits for conductors of electrical energy." B. Verity. Dated September 5.

14047. "Improvements in electric motors." T. H. Parker. Dated September 6.

14061. "Improvements in electric ships' binnacle and telegraph or indicator lamps." T. W. Watson and A. H. Watson. Dated September 6.

14086. "Improved means for effecting the insulation of electrical transformers, switches, switchboards, fuses, commutators, and commutator brushes." W. C. Johnson and S. E. Phillips. Dated September 6.

14113. "Improvements in switches for electrical propulsion purposes." M. Immisch. Dated September 7.

14114. "Improved switch for electrical tramcars." M. Immisch. Dated September 7.

14116. "Disengaging apparatus actuated by electricity." C. Blanke. Dated September 7. (*Complete.*)

14155. "Improvements in primary batteries." C. A. McEvoy. Dated September 7.

14162. "Improvements in treating and rectification or ageing alcohol or alcoholic liquors or the like by electricity." A. de Meritens. Dated September 7. (*Complete.*)

14169. "Improvements in or connected with telephones." R. Steenberg. Dated September 9.

14189. "Improvements in arrangements and mechanism for storing power, and applying the same to start or assist in starting electric, gas, and other engines, tram cars, omnibuses, and other vehicles." W. Giffard. Dated September 9.

14206. "An improvement in battery jars for electrical and other similar apparatus." J. Bridger. Dated September 9.

14215. "Improvements in and relating to the transmission of electric impulses for the purposes of telegraphy and telephony." G. Forbes. Dated September 9.

14232. "Improvements in magneto-electric machines." H. J. Allison. (Communicated by A. S. Fitch, United States.) Dated September 10. (*Complete.*)

14249. "An improvement in ceiling fixings for electric lights and switches." J. O. Girdlestone and S. B. Tatham. Dated September 10.

14321. "Improvements in and relating to the brush-holders of dynamo-electric machines." G. E. Dorman. Dated September 11.

14333. "An improved incandescence lamp mounting with current interruptor." F. W. Arnold. Dated September 11. (*Complete.*)

CORRESPONDENCE.

Incandescence Lamp Slide Rule.

My attention has been drawn to a paragraph in your issue of September 6th, in which you reproduce a letter of Mr. S. Bottone having reference to a form of slide rule designed by me for facilitating calculations respecting incandescence lamps. Mr. Bottone there suggests, with great confidence of statement, that my rule differs in no essential respect from one previously designed by Mr. John Innes, and for the sale of which he appears to be the agent. Allow me to state that previously to reading your note I had never heard of the name of Mr. John Innes in connection with any slide rule, and was in complete ignorance that he had designed one. Furthermore, on referring to the somewhat rough sketch given in the *English Mechanic* of July 27th, 1888, I find that the differences between my design and his are considerable. My object was to produce the very simplest form of mechanical calculator for performing glow-lamp calculations, and *nothing else*, and hence free from every complication due to the presence of other scales. His aim, according to his own statement, seems to have been to include all kinds of calculations about horse-power, copper deposited per hour, &c., &c., and the eleven scales in his rule render it considerably more complicated than do the four identical scales on mine. If the object of a slide rule is to perform a multiplicity of calculations the well known rules of Gravet and Boucher are adequate to do all these things, and much more. My experience, however, is that in the factory nothing can be too simple, and my purpose was to produce a slide rule for use there with as little complication about it as possible, and not as much.

There are other differences of detail into which I need not enter; suffice it to say in reply to Mr. Bottone:

1. That I was not in any way indebted for my ideas to the rule designed by Mr. Innes, and did not know of its existence. The notion of it occurred to me certainly before July, 1888.

2. That my rule and his are not the same in design, and not entirely the same in purpose.

3. That so far from describing the rule in the *ipsissima verba* of Mr. Innes, there is not one single paragraph which is the same in the five succinct instructions which are appended to my rule, and the short and very sketchy description which accompanies the design given in the *English Mechanic*.

In conclusion, since writing the above, I have found that in 1882 Profs. Ayrton and Perry described (see "Journal Soc. Tel. Engineers," Vol. XI., p. 277) an electric light calculator which was a circular slide rule, so that neither I nor Mr. Bottone need contend for priority, although I deem it desirable to place on record a counter-statement to his very confident assertion as to the "source from which the idea of the slide rule was originally derived."

J. A. Fleming.

Electrical Execution.

I wish to express my thanks for the fair and able article upon electrical execution in your issue of August 30th. As a contrast I inclose a clipping from the New York *Sun*, in which correspondence, stolen from my desk during my absence from the city, has been distorted and combined in a way designed to injure me, my signature being boldly forged to the letters alleged to be written by me. This article was preceded and followed by violent editorials personally attacking me, all of which bear the ear-marks of a certain alternating current company—for instance, the Thomson-Houston Company, the largest user of the alternating current in this country, is called a "continuous-current" company. My offence seems to be that I proved the alternating current to be deadly when certain interested persons claimed that it was harmless; that when required by the State of New York to furnish execution apparatus I chose that which had killed dozens of innocent men, and purchased it of a company which had it for sale; and that I would not believe that twice two made six; and organised a competitive test of the Westinghouse alternating system, which is "guaranteed to give 50 per cent. more light per lb. of fuel" than any other, against the Thomson-

Houston apparatus, and tried to get the United S
and Edison systems into the test. All of these
were known to the State authorities and to most of
electric light fraternity months ago, as I issued in A
the enclosed circulars and distributed them wi
Notwithstanding which some of the American elec
papers published the *Sun's* attacks without comin
get the truth of the matter. Since the publication of
Sun's article the alternating current has had four m
victims: J. Kemmerle, fruit dealer, who touched
incandescent lamp while standing on a wet sidewal
Pueblo, Colo., on August 29th; D. A. Henry, Supe
tendent East River Electric Light Company, ki
September 2nd by touching primary wires; H. P. F
lineman, who at Buffalo, N.Y., fell upon insulated w
carrying the primary current on September 5th; an
telephone lineman a day or two ago at St. Louis, Mo., w
made a ground connection with the Westinghouse sys
It is evident that these deaths and many others w
caused by confidence in the reckless statements c
cerning the safety of this current. A Westingh
company operating in this city calls itself the S
Electric Light Company. I prefer to be the subje
purchased newspaper abuse than to be the millio
whose apparatus has killed fifteen or twenty inno
men, but who nevertheless states over his own sig
ture that "pressures exceeding 1,000 volts (alternati
current) can be withstood by persons in ordinary hea
without experiencing any permanent inconvenience."

Harold P. Brown

Electric Traction.

The misstatements in the letter of Mr. A. J. Jarm
compel me to ask for the insertion of a reply upo
subject which has, I am afraid, little interest to anyo
but those directly concerned.

Firstly, the truck or trolley for carrying cells was
invented or designed by Mr. Jarman, and has ne
been claimed by him until now. He had neither tr
nor plan, for the simple reason that the cells could
be withdrawn endwise.

Secondly, he states that upon *my* appeal t
Attorney-General compelled me to insert a di
claimer. Now, he knows as well as I do my coun
offered to insert the very words now printed in m
specification, and I fail to see how it affects my pate
I have never claimed two armatures on one shaft, a
it is a matter of indifference to me whether I mou
them on one shaft or two.

Mr. Jarman gives you an extract from the Com
troller's decision, respecting which the Attorney-Gene
said: "I think that the Comptroller has gone too far
this case."

I am prepared to admit I gained a large part of
knowledge while with Mr. Jarman, and it was upon t
principle "that from failures improvements spring
and as he had little else but failures during that peri
it stands to reason I had a grand field to make improv
ments, which when offered to him were ridiculed.

I am quite satisfied with the matter as it now stand
and I regret I have neither the time, the inclinati
nor the ink-slinging ability to go further into t
matter with him, until he compels me, by dir
threats, to do so. But if any of your readers ta
sufficient interest in the system to call by appointm
I shall be only too glad to show it to them.

W. D. Sandwell

I have observed with pleasure, in the very interest
correspondence now appearing in your paper, that
A. J. Jarman again states—which, by the way, he st
some 18 months ago—that several cars will before l
be in operation. Will he be good enough to tell
when and where this desired exhibition is to t
place, as many doubtless, like myself, would gladly a
themselves of an opportunity to see so excellent a p
posal put into practical action?

Harry Will